

SPACE RESEARCH IN SWEDEN

2002-2003

Swedish National Space Board

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PART I

Overview of Swedish Space Activities related to Research 2002-2003

National Organisation of Space Activities

Swedish National Space Board

(Swedish: Rymdstyrelsen)

The Swedish National Space Board (SNSB), under the Ministry of Industry, Employment and Communications, is the central governmental agency responsible for national and international space activities in Sweden. SNSB is primarily an R&D agency and acts as research council for the distribution of government funds (Ministry of Education and Science) for basic space research.

The responsibilities of SNSB include

- initiation of research, development and other activities connected with the Swedish space and remote sensing programmes
- co-ordination of Swedish activities within the fields of space technology, space research, and remote sensing
- distribution of government appropriations for Swedish space activities
- authorisation and supervision of space activities in accordance with space law
- maintenance of contacts with international organisations and institutions operating within the field of space activities and remote sensing.

SNSB is responsible for the planning and the co-ordination of Sweden's participation in the programmes of the European Space Agency (ESA).

The memberships in the board of SNSB and its two advisory committees for space research and remote sensing are listed below. SNSB has 18 employees. Per Tegnér is Director General of SNSB.

Members of the Board (2004)

P Tegnér, SNSB (*Chairman*)

L Beijer, Member of Parliament

C Fredriksson, EuroFutures, Stockholm

M Sandström, Swedish Defence Research Agency, Stockholm

M Larsson, Department of Physics, AlbaNova, Stockholm University

M Mikes-Lindbäck, ABB Corporate Research, Västerås

M Ågren, Swedish Meteorological and Hydrological Institute, Norrköping

Space Research Advisory Committee (2004)

M Larsson, Department of Physics, Stockholm University (*Chairman*)
 E Friis-Christensen, Danish Space Research, Copenhagen, Denmark
 G Grimvall, Theoretical Physics, Royal Institute of Technology, Stockholm
 D Hughes, Dept. of Physics and Astronomy, University of Sheffield, UK
 I Isaksen, Department of Geophysics, Oslo University, Norway
 T Pulkkinen, Finnish Meteorological Institute, Helsinki, Finland
 Christoffel Waelkens, Institute for Astronomy, Leuven

Secretariat:

K Dannenberg
 M Lannerö
 P Magnusson
 L Nordh

Remote Sensing Advisory Committee (2004)

L-E Liljelund, National Environmental Protection Agency (*Chairman*)
 C Andersson, Stockholm
 A Engberg, Lantmäteriet, National Land Survey
 B Håkansson, Swedish Meteorological and Hydrological Institute
 E Liljas, Swedish Meteorological and Hydrological Institute
 E Normark, Holmen Skog AB
 H Olsson, Swedish University of Agricultural Sciences
 L Ulander, Swedish Defence Research Agency

Secretariat:

E Bergstedt
 G Boberg
 K Dannenberg
 M Nilsson

Research Societies**Association of Swedish Space Scientists**

(Swedish: Svenska rymdforskarens samarbetsgrupp, SRS)

Active space scientists are members of this group, whose main task is to provide a forum for discussions on joint projects within the scientific programme.

Secretary: Dag Linnarsson
 E-mail: dag.linnarsson@fyfa.ki.se
 URL: <http://www.astro.su.se/srs/>

Swedish Astrobiology Network (SWAN)

The SWAN network is a non-profit association of Swedish researchers, who share an interest in astrobiology.

Chairman: Nils Holm

E-mail: nils.holm@geo.su.se

URL: <http://www.astrobiologi.nu>

Swedish Space Industries

The technical implementation of the national programme is mainly contracted by SNSB to the state-owned **Swedish Space Corporation** (SSC, in Swedish: “Rymdbolaget”). The Odin satellite is an example. The company is responsible for developing many scientific instruments for ESA’s microgravity research programmes. SSC was the prime contractor for the ESA technology demonstrator Smart-1, which reached the moon in November 2004 with the help of solar electric propulsion. SSC is also active on the commercial market. The space base Esrange is managed by SSC.

The private part of Swedish space industry is dominated by **Saab Ericsson Space** and **Volvo Aero Corporation**. Both companies have extensive technical development and manufacturing for both the commercial space market and for ESA.

There are many smaller Swedish companies with products for applications in space, as exemplified in the table below.

Industry	Address	Telephone, Fax, WWW	Fields of activity
ACR Electronics AB	Box 99 619 00 Trosa	Phone: +46 156 191 77 Fax: +46 156 191 88 home.swipnet.se/~w-12495	-Mechanical and electronic design and construction -Spacecraft structure, sensor technology -Microwave antennas
Aerotech Telub AB	732 81 Arboga	Phone: +46 589 800 00 Fax: +46 589 61 16 52 www.aerotechtelub.se	Assembly, integration and testing of small satellites, ground equipment for testing satellites, antennas for satellites
C2SAT	Kungsvägen 26, 191 45 Sollentuna	Phone: +46-8-748 01 40 Fax: +46-8-748 01 43, www.c2sat.com	High performance stabilised antenna systems, utilised onboard vehicles and vessels in

FOI, Swedish Defence Research Agency	Box 11021 161 11 Bromma	Phone: +46 8 634 10 00 Fax: +46 8 25 34 81 www.foi.se	motion Aerodynamic R&D, wind tunnel tests
Gaisler Research	Första Långgatan 19, 413 27 Göteborg	Phone: +46-31-775 86 50 Fax: +46-31-42 14 07 www.gaisler.com	Digital hardware design for ground-based and aerospace applications
Metria Kiruna	Box 820 981 28 Kiruna	Phone: +46 980 670 00 Fax: +46 980 670 67 www.lantmateriet.se	Production and delivery of geographic data
Metria Miljöanalys	Box 24154 104 51 Stockholm	Phone: +46 8 579 972 70 Fax: +46 8 579 972 80 www.lantmateriet.se	Delivery of data, systems and support for geographic information
Nordic Satellite AB	Vretenvägen 10 SE-171 54 Solna Sweden	Phone: +46 8 505 645 00 Fax: +46 8 28 24 80 www.nsab.se	Owns and operates three communications satellites.
Omnisys Instruments AB	Gruvgatan 8 421 30 Västra Frölunda	Phone: +46 31 734 34 00 Fax: +46 31 734 34 29 www.omnisisys.se	Scientific instruments for space reserach (RF/microwave area)
Polymer Kompositer AB	Aminogatan 34 431 53 Mölndal	Phone: +46 31 86 40 54 Fax: +46 31 86 45 14 www.polymerkompositer.se	Metallized carbon fibre structures
Rymdbolaget, Swedish Space Corporation	Box 4207 171 04 Solna	Phone: +46 8 627 62 00 Fax: +46 8 98 70 69 www.ssc.se	-Launch of sounding rockets and balloons -Reception of data from remote sensing satellites -Performs TT&C operations on polar orbiting satellites - -Telecommunication-services -Airborn Maritime Surveillance System -Small satellites, instruments for sounding rockets, balloons -Microgravity payloads
Saab Ericsson Space	405 15 Göteborg	Phone: +46 31 735 00 00 Fax: +46 31 735 40 00 www.space.se	-Spacecraft systems -Computers and data handling -Sensor system mechanisms -Spacecraft structures -flight control systems for sounding rockets

			-Microgravity payloads -Small satellites -Microwave antennas -Microwave electronics and fibre optics
Spacemetric	Tingsvägen 19 191 61 Sollentuna	Phone: +46 8 594 770 80 Fax: +46 8 594 770 89 www.spacemetric.se	Platformindependent software for production of satellite images
Spectrogon AB	Box 2076 183 02 Täby	Phone: +46 8 768 09 80 Fax: +46 8 768 72 05 www.spectrogon.com	Optics for scientific instruments
SweDish Satellite Systems AB	Hälsingegatan 40 Box 6495 113 82 Stockholm	Phone: +46 8 587 950 00 Fax: +46 8 587 950 05 www.swe-dish.se	Production of portable uplinks
SwedPower AB	Box 527 162 16 Stockholm	Phone: +46 8 7396000 Fax: +46 8 7396226 http://www.swedpower.se	Development and application of remote sensing and geographical information system technologies
TeleWide AB	Nålvägen 4 931 57 Skellefteå	Phone: +46 910 173 40 Fax: +46 910 173 48 www.telewide.se	Development of a groundbased multisatellite antenna
Volvo Aero Corporation	461 81 Trollhättan	Phone: +46 520 940 00 Fax: +46 520 340 10 www.aero.volvo.se	-Production of combustion chambers and nozzles for Viking (Ariane 4) -Development of nozzle and turbines for Vulcain (Ariane 5) -Technology programme in pump systems, nozzles and combustion
YoYo Technology AB	Regeringsgatan 82 111 39 Stockholm	Phone: +46 8 454 8650 Fax: +46 8 10 46 32	Equipment for in-flight and Earth-based resistance exercise

International Co-operation

Sweden is one of the founding members of the European Space Agency, **ESA**. Sweden participates in the mandatory basic and scientific programmes as well as in the optional programmes on Earth observation, telecommunications, technology, microgravity, launcher development, International Space Station and navigation. The Swedish contribution to ESA accounts for about 70 % of the SNSB budget.

Bilateral co-operation on space science and applications, primarily the SPOT-programme for remote sensing, is carried out between Sweden and **France** under agreements with Centre National d'Etudes Spatiales, CNES.

The Vegetation Programme is developed jointly by **France, the European Commission, Belgium, Italy** and Sweden.

Sweden, **Canada, Finland and France** are co-operating on the scientific satellite project **Odin**, which was launched in February 2001.

Memoranda of Understanding have been concluded as basis for co-operation with SNSB's counterparts in **Austria, Canada, India**, the People's Republic of **China** and **Russia**. Sweden is also engaged in other bilateral co-operative projects carried out on ad hoc basis.

Sweden is a member of **CEOS** (Committee on Earth Observation Satellites) since 1991. Sweden has been a full member of the ad hoc Group on Earth Observations (GEO) from the very beginning when it was established as a result of the Earth Observation Summit in Washington 2003, in order to prepare a 10-year implementation plan for a coordinated, comprehensive, and sustained Earth observation system of systems.

Sweden is also a member of the **UN Committee for Outer Space, COSPAR** (Committee on Space Research), **Intelsat, Eutelsat, Inmarsat** and **Eumetsat**.

Esrange

Esrange is a Swedish space range with sophisticated facilities. The geographical location, north of the Arctic Circle, offers several unique advantages for space and environmental research, testing of new aerospace techniques and for control and operation of various types of satellite. The base is managed by the Swedish Space Corporation (SSC) and was established in 1966.

Space research activities at Esrange are often carried out as an ESA special project with one or several of the countries Germany, France, Switzerland, Norway and Sweden involved. Studies of high latitude phenomena, astronomical observations or studies during microgravity are of particular interest. Sounding rockets, stratospheric balloons, aircrafts and ground based instrumentation frequently operate simultaneously during scientific campaigns at Esrange.

Sounding rockets have been launched at Esrange since 1966. A large restricted area on land enables quick recoveries of payloads and contributes to the fact that the base is part of the largest overland test range for aerospace vehicles in Western Europe (NEAT, Northern European Aerospace Test range).

The range also has long experience of releasing scientific high altitude balloons and has during recent years developed into a centre for international ozone research campaigns. Scientific payloads can be flown over Finland and Russia or even further in circumpolar flights.

Besides scientific research Esrange is involved in a large number of satellite operations. The Esrange Satellite Station was established in 1978 for earth observation satellites. Today the station has extended to a communication centre for polar orbiting satellites with several independent antennas and processing systems running. The Esrange Satellite Station controls and operates satellites or receives and records data from satellites on behalf of customers. Remote customers can be connected to the station for access to their satellites in real time or they can place their own station at Esrange, as done by the Japanese space organisation JAXA.

A satellite control centre for telecommunication satellites is also located at Esrange and ESA has chosen to establish its own ground station for European earth resource satellites at Salmijärvi, in the vicinity of Esrange.

All satellite stations above are operated by the Swedish Space Corporation, which also provides a world wide network of ground satellite stations. Together with an American partner, SSC operates the global network *Prioranet*, providing near-global ground communications coverage of spacecraft in any Earth orbit.

Sounding Rockets

The rocket range was originally established for European studies of space phenomena in the arctic region, for instance northern lights. Today many other topics are of interest such as experiments during microgravity, studies of the atmosphere with environment and climate change in focus and validation of satellites. Rocket campaigns are usually carried out as international co-operative projects with customers from all over the world.

Table of sounding rocket launches 2002-2003

Missions	Launch dates	Rockets	Comments
Maser 9	2002 March 13	1 Skylark 7	ESA microgravity experiments
SAGE Validation	2003 January 13–30	23 Super Lokis	NASA atmospheric studies to validate the SAGE instrument on the satellite Meteor III
MacWave	2003 January 24–30	2 Terrier-Orion, 22 Super Lokis	NASA atmospheric studies
Maxus 5	2003 April 1	1 Castor 4B	ESA microgravity experiments
Texus 40	2003 April 8	1 Skylark 7	DLR microgravity experiments

Balloons

The period 2002-2003 saw a continuation of international campaigns at Esrange for space and atmospheric research. As usual a large number of balloons were launched to measure the upper polar stratosphere, in particular studies related to ozone depletion and other environmental issues. Some of these payloads had a dual missions in order to validate data from ESA:s satellite Envisat.

Two balloon launches were also carried out within the French led international Archeops project. The object was to observe the cosmic microwave background radiation to learn more about the processes that took place after the Big Bang. A 1.5-meter telescope was lifted up to 35.9 km and could measure for as long as 18 hours in polar darkness.

In addition one aerodynamic test and two drop tests of future space shuttles systems were performed of the Japanese HSFV vehicle and the German Phoenix vehicle. Testing of aerospace vehicles is a new promising field of application at the Esrange facility.

In parallel to the balloon campaigns above 17 advanced technical test flights of balloon systems were performed by the French space organisation CNES as well as the Swedish Space Corporation.

Table of balloon launches 2002-2003

Missions	Launch dates	Comments
PRE VORCORE	2002 Jan 9 – Feb 5	9 technical flights
Archeops	2002 Jan 15 – Feb 7	3 flights for astronomy
SALOMON	2002 January 21	Atmospheric measurements
CIPA	2002 February 12	Atmospheric measurements
HALOZ 2	2002 March 2	Atmospheric measurements
Test flight	2002 March 13–17	2 technical flights - MIR
Envisat validation 1	2002 August 3–18	5 flights for atmospheric measurements
Test flight	2002 November 25	Technical flight - EBASS
CIPA / Ozone	2002 December 3	Atmospheric measurements
Aerosol / Frostpoint	2002 December 3	Atmospheric measurements
CIPA	2002 December 4–7	3 flights for atmospheric measurements
SOLVE 2-1	2002 December 16	Atmospheric measurements
Envisat Validation 2	2003 Jan 10 – Mar 30	13 flights for atmospheric measurements
Aerosol / Frostpoint	2003 January 16–22	2 flights for atmospheric measurements
SOLVE 2-2	2003 March 31	Atmospheric measurements
HSFD	2003 June 5 – July 2	2 flights for aerodynamic test
PHOENIX	2003 October 20–21	2 flights for Phoenix FTS Drop tests

Other Space-Related Facilities and Installations

The **Onsala Space Observatory** operates two radio telescopes principally for radioastronomical observations. It also serves as a data centre for the **Odin** satellite observatory and in the planning of the scientific operations of the mission. The Observatory is also a partner in the newly constructed **APEX** telescope, the Atacama Pathfinder Experiment, on Llano Chajnantor at an altitude of 5000 m in the Chilean Andes, and is building and installing several of the millimetre/sub-millimetre wave receivers. Additionally, Onsala is heavily involved in the Atacama Large Millimetre Array (ALMA) and staff are working on various aspects of this unique European-US collaborative venture.

The **EISCAT** Scientific Association, a collaboration between Finland, France, Germany, Japan, Norway, Sweden and the United Kingdom, has installed a multistatic incoherent scatter facility in the auroral zone, comprising a system of stations at Tromsø (Norway), Kiruna (Sweden) and Sodankylä (Finland).

Sweden operates major ground facilities in support of Earth observation satellites including a new X-band receiving station at **Sturup** in southern Sweden. A joint Scandinavian Intelsat ground station is located at **Tanum** on the west coast of Sweden.

A **human rated centrifuge** for hypergravity research is situated at the **Karolinska Institute** in Solna, near Stockholm.

National Scientific Space Programme

Part II of this report gives an overview of the Swedish space research groups. These cover a broad range of disciplines, such as astrophysics, space physics, atmospheric research, remote sensing, material sciences, and physiology. The research is supported by research grants from SNSB as well as other funding agencies.

A large part of the national research programmes utilises space instrumentations made possible through ESA programmes. Some disciplines also benefit extensively from satellites, sounding rockets and balloons financed on a national basis or through bi/multilateral cooperation. Finally, some research groups utilise third party space hardware.

Swedish Research Satellite Programme

Viking - Sweden's first scientific satellite

Viking was launched by the launch vehicle Ariane from Kourou in 1986. The mission ended in May 1987.

The scientific objective of the Viking satellite was to study the ionospheric and magnetospheric phenomena at high geomagnetic latitudes in the altitude region up to about two Earth radii. Simultaneous measurements were made of electric and magnetic fields, particle distributions, plasma composition and waves as well as imaging in the ultraviolet of the aurora beneath.

Viking was operated from Esrange, Kiruna, where the telemetry data from the satellite was received and processed on a real time basis. Viking has yielded scientific results that go far beyond expectations. Also from an industrial point of view Viking was a success.

Freja - Sweden's second scientific satellite

Freja, a scientific satellite in collaboration with Germany, carried instruments for research of the aurora. It was launched on 6 October 1992 as a "piggy back" on a Chinese carrier, Long March 2 and was fully operational until 6 October 1996.

The mission target was the auroral zone. Freja carried detectors for high-energy particles, magnetic and electric wave experiments as well as electric field sensors and a UV imager. Freja had an almost ten times higher downlink data rate than Viking. It used an S-band downlink with a maximum experiment data rate of 500 kbps.

Two reception stations collected the scientific data. In northern Sweden, data was received at Esrange Space Centre, Kiruna; the other station was the Prince Albert Satellite Station in Canada's Saskatchewan province. Prince Albert's location was ideal for receiving real-time data when Freja traversed the auroral oval.

Freja was a scientific and technical success and has yielded a large amount of new scientific results.

Astrid 1

Astrid 1, the first Swedish microsatellite was launched in January 1995 with a Russian launch vehicle, COSMOS, from Plesetsk in Russia. Scientific data of high quality was obtained during one month and the spacecraft operated for 6 months. The total mass was approximately 20 kg and the payload consisted of instruments for measuring neutral particles and electrons in the magnetosphere and of UV photometers for imaging the aurora.

Astrid 2

The second Swedish microsatellite, the 35-kg Astrid 2, was launched from Plesetsk into a 1000 km altitude polar orbit on 1998 December 10. A transmitter and receiver station was situated at the Swedish Space Corporation in Solna, and a receiver station in Antarctica. The satellite was operational until 1999 July 24 and yielded a large set of data on electric and magnetic phenomena occurring in the ionosphere and magnetosphere. The 10-kg payload consisted of an instrument for measurements of electric and magnetic fields (EMMA), a Langmuir probe for studies of fine temporal and spatial structures of the plasma (LINDA), an electron and ion spectrometer (MEDUSA), and a photometer for imaging of the aurora (PIA).

Odin Orbital Observatory

The Odin satellite combines two scientific disciplines on a single spacecraft. One is astronomical studies of star formation and the early solar system. The second discipline is aeronomy and here Odin addresses the mechanisms behind the depletion of the ozone layer in the Earth's atmosphere and the effects of global warming. The Swedish Space Corporation (SSC), on behalf of the Swedish National Space Board (SNSB) and the space agencies of Canada (CSA), Finland (TEKES) and France (CNES), has developed the satellite and is responsible for its operation.

Odin is in operation since its launch with a Start-1 rocket from Svobodny in eastern Russia on 20 February 2001. The satellite was placed very precisely into a 620 km sun-synchronous, polar orbit with an ascending node near the terminator. The satellite is operated from a ground station at Esrange in northern Sweden.

The main instrument on Odin is an advanced radiometer which is used for both the astronomy and aeronomy missions. For the aeronomy mission the payload is complemented by an imaging grating spectrometer named OSIRIS (Optical Spectrograph and InfraRed Imaging System).

The radiometer consists of four tunable receivers operating in the frequency range 486-580 GHz and one fixed-tuned receiver at 119 GHz. The sub-mm receivers are tunable to cover a bandwidth of 17 GHz each. The frequency resolution is selectable between 0.1 and 1 MHz at instantaneous bandwidths of 0.1 and 1 GHz, respectively. All receivers have the same viewing direction and are fed by a 1.1 meter double-reflector (Gregorian) telescope. The resulting beam-size is on the order of 2 arc minutes for the high frequency receivers and 9 arc minutes for the 119 GHz receiver.

OSIRIS provides simultaneous observations with a UV/Visible spectrometer covering the spectral range 280-800 nm with a resolution of 1-2 nm and an IR imager with three channels, two at 1,7 μm and one at 1,53 μm , each having a passband of 10 nm.

Odin is 3-axis stabilised with an attitude control system suitable for both astronomy and aeronomy modes. It can stare at astronomical targets for hours with accuracy better than 15 arc seconds or scan the limb of the Earth's atmosphere between 10 km and 120 km altitudes, 40 times per orbit, with a reconstructed accuracy of 1.2 arc minutes. The entire satellite is pointed towards the targets.

The basic data reduction and calibrations are made at Onsala/Chalmers for the radiometer and at Saskatoon (Canada) for OSIRIS. For astronomy this leads directly to data suitable for scientific analysis. For aeronomy the radiometer data go through additional refinement using algorithms developed under responsibility by the Global Environmental Measurements Group at Chalmers with support from the Observatory in Bordeaux and the Atmospheric Physics Group at Stockholm University. The corresponding production of so called Level 2 data is made under the responsibility of a group in Sodankylä, Finland.

Odin data are being used to study the global distribution of species of key importance for understanding the physics and chemistry underlying ozone destruction and global warming. Among such species are ozone, various chlorine and nitric compounds, hydrogen compounds and aerosols. Odin has an unprecedented capability for measuring mesospheric water vapour and making very sensitive determinations of the abundance of e.g. chlorine monoxide.

Observations of water vapour, molecular oxygen and ammonia are among the main astronomy drivers of the mission. Odin has observed water vapour from comets and galactic molecular clouds, in some cases from both H_2O^{16} (557 GHz) and H_2O^{18} (548 GHz). Despite significant efforts molecular oxygen (119 GHz) has not yet been detected. The derived abundance limits are significantly lower than model predictions and in the order of 10 times lower than those obtained by SWAS. The ammonia line at 572 GHz has been detected in several galactic

molecular clouds and star-forming regions. Many astronomical results from Odin are collected in a special issue of *Astronomy and Astrophysics*, 402, 3 (2003).

Odin is foreseen to be operational at least until Spring 2006.

Munin

This 6-kg nano-satellite for space plasma measurements was developed by the Swedish Institute of Space Physics. It was launched as piggy back on a Delta II rocket on 2000 November 21 and was operated for 53 days.

NanoSpace 1

The Ångström Space Technology Center in Uppsala is currently developing a small technology satellite for tests of miniaturized satellite platform equipment. The inclusion of scientific instruments for magnetospheric and ionospheric research is currently under investigation.

Swedish Research Involvement in Other Satellite Projects

The Institute of Space Physics in Kiruna and Uppsala and the Space Physics Group at the Alfvén Laboratory in Stockholm provided instruments to the ESA **Cluster II** satellites, which were launched on two Russian boosters in 2000. The Scandinavian data centre for Cluster II is situated at the Alfvén Laboratory. The Institute of Space Physics is also involved at co-investigator level in the Chinese **Double Star** project.

The Swedish Institute of Space Physics in Lund has a space weather programme utilising data from **SOHO** and other satellites.

The Institute of Space Physics in Uppsala participates in the joint NASA/ESA mission **Cassini/Huygens** to the Saturn system and have provided hardware and software for a Langmuir Probe.

The institute of Space Physics in Uppsala and Kiruna, and the Space Physics Group at the Alfvén Laboratory in Stockholm, in close collaboration with Finnish and Norwegian groups, are responsible for part of the plasma instrument package on the **Rosetta** orbiter, that was launched in January 2004. A research group at the Astronomical Observatory in Uppsala is scientifically involved in several instrument teams related to the Rosetta mission. Filters for the scientific camera on the orbiter were made by the Swedish company Spectrogon.

The Stockholm Observatory, in collaboration with Irish colleagues, is responsible for filters for the MIRI instrument on the NASA/ESA **James Webb Space Telescope**. The Observatory is also involved at CoI-level in the JEM-X

experiment on the ESA satellite **Integral** (launched in October 2002). Researchers at the observatory are also actively involved in preparing for a future interferometric cluster of satellite telescopes, **Darwin**, for the detection of exoplanets.

A research group at the Royal Institute of Technology is responsible for the anticoincidence shield for the Italian-led satellite experiment **PAMELA**, to be launched in 2005 for studies of the cosmic flux of antimatter.

Groups at AlbaNova (Royal Institute of Technology and at Stockholm University) are responsible for the CsI calorimeter on the gamma-ray observatory **GLAST** (to be launched in 2006).

A research group at the Astronomical Observatory in Lund took an active part in the Nordic Data Analysis Center in support of the ESA mission **Hipparcos** and is now applying the high precision astrometry to new branches of astronomy. The group is heavily involved in preparations for the ESA cornerstone project **GAIA**, an interferometric astrometry mission.

The Onsala Space Observatory takes an active part in the Russian interferometer project **RadioAstron** and in the Japanese interferometer mission **HALCA** (previously VSOP; launched in 1997). The Onsala group together with research groups at Chalmers University of Technology and the Stockholm Observatory are involved in the forth ESA cornerstone mission, **Herschel**. They have built a facility for testing mixer assemblies for the HIFI instrument, and they will provide mixers for the highest frequency band of HIFI. Staff at Stockholm Observatory are involved in development of software and interfaces for the instrument simulator for Herschel/Spire.

The Stockholm Observatory and the Astronomical Observatories in Uppsala and Lund participate with several guest investigator programmes on the Hubble Space Telescope (**HST**) and other observatory satellites.

Sounding Rockets

Within the Swedish national programme the sounding rocket **Hygrosond 2** was launched from Esrange in 2001 to an altitude of 95 km. Concentrations of water vapour from 20 to 90 km were obtained with an instrument developed within a research programme in Atmospheric Physics at the Department of Meteorology, Stockholm University (MISU). The launch was part of a rocket/balloon campaign to validate observations from the Odin satellite.

During the reporting period researchers at MISU, in collaboration with colleagues from the Naval Research Laboratory, Washington DC, planned for the launch of the rocket project **MAGIC** in early 2005, with the main purpose of searching for microscopic dust particles of interplanetary origin.

Earth Observation

The Swedish National Space Board is responsible for funding of Swedish research and development activities within the area of Earth Observation. The funding includes financial support to research groups, to method and technique development and to users who intend to start or expand the use of remote sensing data.

Research

SNSB supports a number of Swedish research groups that work with remote sensing. The research is carried out within areas such as forestry, global monitoring, climate change, meteorology, geodesy and atmospheric physics. At the moment global monitoring and activities linked to the European initiative GMES (Global Monitoring for Environment and Security) have high priority. More information about the remote sensing research carried out in Sweden can be found on page xxx.

Examples of Earth Observation in practical use

The Swedish National Board of Forestry is one of the big remote sensing users in Europe. The board uses SPOT and Landsat data in a GIS-based forest support system. Every year they produce a total land coverage for forestry control in Sweden that is used for change detection on each of the 100 local offices. This means that more than 500 people use the data, for example to check if felling is done according to what has been reported to the board.

The Swedish Meteorological and Hydrological Institute is another big remote sensing user. They are also carrying out many important research and development projects within meteorology and climate. One project that soon will lead to operational use is carried out together with Chalmers University of Technology and Lantmäteriet (the National Land Survey). The three groups are developing a system where data from SWEPOS (a national network of reference stations for GPS) can be used by meteorological institutes within weather forecasting.

Metria is the biggest Swedish deliverer of remote sensing data, systems and applications. One example of their work is the use of earth observation data to produce support for efficient and cost-effective planning and management of refugee camps. Detailed maps of camp infrastructure, thematic maps and digital elevation models are produced from high-resolution satellite images. Relief organisations can integrate the information directly into their decision-making and operational process.

Researchers at Uppsala University are developing an operation system for monitoring the water quality of Lakes Vättern and Vänern, Sweden's two largest lakes. The lakes are important water bodies for economic, ecological and aesthetic reasons, and for over 30 years Sweden has invested large sums of money to monitor their water quality by traditional means. Now it will be possible to estimate the concentrations of chlorophyll, dissolved organic matter and

suspended particulate matter, using satellite sensors like MODIS and MERIS. These data will supplement the traditional monitoring efforts.

ESA

Sweden is a member state in the European Space Agency (ESA) and participates in ESA's Earth Observation programme. Earth Observation is a big part of the ESA activities and has always been of great importance to Sweden.

ERS-1 was the first European remote sensing satellite. It was launched in 1991 and the mission ended in March 2000. ERS-2 took over the operational services in 1996 and it still produces data. The most important instrument on board the satellites is a synthetic aperture radar that provides sharp pictures even in the dark or through cloud cover. ERS-2 gathers climatic and environmental data from the surface of the earth and provides information on the propagation speed of ocean waves, the structure of the arctic ice as well as wind speed and direction.

In 2002 ESA launched a new earth observation satellite, Envisat. It is an impressive satellite with its 25 metres and 8000 kilogram and it carries 10 different, very advanced instruments. Envisat is primarily concerned with monitoring the Earth's environment and climatic changes and provides measurements of the atmosphere, ocean, land, and ice.

SPOT

Sweden participates in the SPOT programme that is carried out in co-operation between France, Belgium and Sweden. SPOT consists of a series of earth observation satellites and the first satellite, SPOT 1, was launched in 1986. The fifth and last, SPOT 5, was launched in 2002. Important applications of SPOT imagery lie within the areas of mapping, telecom, forest management, agriculture, environmental monitoring, geology and planning.

On board SPOT 4 and SPOT 5 is also the Vegetation instrument, producing high frequency low resolution images. This is a sensor developed jointly by the European Commission, Belgium, France, Italy, and Sweden. The Vegetation system enables daily and global monitoring of the entire continental biosphere and crops. It was specially designed to track the vegetation, particularly in agricultural production, forestry and surveillance of the land environment worldwide. Free Vegetation products can be found at www.vgt.vito.be.

GMES

As one of the founders of the Global Monitoring for Environment and Security (GMES) initiative back in 1998, Sweden has been very active in promoting the development of operational remote sensing for environment purposes mainly. GMES aims at co-ordinating existing as well as new technologies and systems to better meet a structured demand for information on the part of European, national, regional and local decision-makers and users. GMES is intended to make full use of data collected from space-borne, airborne and in-situ observation systems that is then delivered to service providers through an efficient data integration and information management capacity. Sweden participates through different organisations in the predevelopment of a number of different services under ESA

and European Commission projects. In addition, GMES related activities have high priority within the Swedish National remote sensing programme.

Ground infrastructure

Earth observation satellite systems need to be supported by ground infrastructure. The Kiruna region in the far north of Sweden has an advantageous location north of the Arctic Circle that makes it eminent for tracking and control of satellites in polar orbits and reception of data from such satellites. Esrange, the Swedish Space Corporation's ground station outside Kiruna, is in all likelihood the world's busiest earth observation ground station. It supports many earth observation satellites in polar orbit, for example Landsat and SPOT. There is also a major facility for ERS-2 and Envisat at Salmijärvi, also outside Kiruna, that is owned by ESA and operated by staff from the Swedish Space Corporation. The Swedish Space Corporation also has an X-band ground station near Malmö in southern Sweden. This gives Sweden the capability of complete coverage of all of Europe from earth observation satellites in direct reception mode.

PART II

Catalogue of Research Groups

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Introduction

The following catalogue is intended to include all Swedish space research groups that during the period 2002-2003 have been actively involved in research utilizing equipment in space or preparing for space borne equipment. The catalogue is divided into disciplinary categories, and the research groups within each discipline are ordered by geography from the north of Sweden to the south.

In many cases the information appearing in the entries have been received from a member of the research group. In other cases the editors have synthesized the information from other sources, such as research applications or the web. Thus, the responsibility for the correctness and timeliness of the information varies from entry to entry.

Remote Sensing

Centre of Biostochastics, Swedish University of Agricultural Sciences in Umeå

Development of stable, repetitive and quality-assured methods that integrate and optimize the use of different remote sensing techniques applied to satellite data from sensors with different spatial, temporal and spectral resolution, ancillary geospatial data both on forestland and agricultural land, GIS analysis and revised field plot monitoring programs. Advanced stochastic modelling and innovative statistical methodologies are the focus to address these large data streams and to supply the end-users with recommendations of highly reliable classification algorithms in various real applications.

Centre of Biostochastics, Swedish University of Agricultural Sciences, S-901 83 Umeå, Sweden

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<http://biostochastics.slu.se>

Department of Forest Resource Management and Geomatics, Swedish University of Agricultural Sciences in Umeå

Research in remote sensing of forest ecosystems and mountain vegetation. Operational environmental monitoring of Swedish forests, using the combination of satellite images and national forest inventory field plots.

Swedish University of Agricultural Sciences, 901 83 Umeå, Sweden

Contact persons: Håkan Olsson, Mats Nilsson

Phone: +46-90-786 5800 Fax: +46-90-778116
E-mail: hakan.olsson@resgeom.slu.se, mats.nilsson@resgeom.slu.se
<http://www.resgeom.slu.se/default.cfm/>

Centre for Image Analysis, Uppsala University and Swedish University of Agricultural Sciences in Uppsala

Research in remote sensing mainly with methods development and applications to aquatic environmental problems and forestry.

Centre for Image Analysis, Lägerhyddvägen 3, S-752 37 Uppsala, Sweden

Contact person: Ewert Bengtsson

Phone: +46-18-471 34 60: Fax: +46-18-55 34 47
E-mail: ewert@cb.uu.se
<http://www.cb.uu.se>

Workgroup of Aquatic Optics, Department of Limnology, Evolutionary Biology Center, Uppsala University

Interpreting satellite based remote sensing measurements of water bodies, with an emphasis on the lakes. Acquisition and processing of various images (SeaWiFS, MODIS, MERIS, ALI, HYPERION, LANDSAT). Developing lake specific atmospheric

correction scheme. Application of bio-optical modeling for elaboration algorithms to estimate concentrations of optically active substances in water. In situ measurements of water quality for validation of image analyses results.

Department of Limnology, Uppsala University, Norbyvägen 20, 752 36 Uppsala, Sweden

Contact persons: Anu Reinart, Niklas Strömbäck

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 E-mail: anu.reinart@ebc.uu.se; niklas.stromback@ebc.uu.se
<http://www.ebc.uu.se/limno/research/AquaticOptics/optics.html>,
http://www.geoinformatik.geo.uu.se/lake_satellite/

Remote Sensing/GIS Laboratory, Dept. of Physical Geography and Quaternary Geology, Stockholm University

The group undertakes fundamental and applied research in RS/GIS. Our main foci are; glaciological remote sensing including paleo-glaciology, ecological and environmental change detection, marine bio-optics and remote sensing, data-bases and data handling, and geographic information science. We are currently involved in the cal/val of MERIS and ASAR data under the 1st Envisat AO. Our research is funded by the Swedish research councils (SNSB, Formas, VR), the European Space Agency and NASA.

RS/GIS Lab., Dept. of Physical Geography and Quaternary Geology, Stockholm University, S- 106 91 Stockholm, Sweden

Contact person: Johan Kleman

Phone: +46 (0)8 164813, Fax +46 (0)8 164818
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<http://www.geo.su.se/naturgeo/rsgis/index.htm>

Geoinformatics and Photogrammetry, Infrastructure and Planning, Royal Institute of Technology (KTH)

Infrastructure and Planning, KTH, 100 44 Stockholm, Sweden

Contact persons: L E Sjöberg, Anders Boberg

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 E-mail: abg@geomatics.kth.se
<http://www.kth.se>

Swedish Meteorological and Hydrological Institute

The research is focused on SAR and SSM/I sea ice applications in the Baltic Sea for operational products and in the Arctic Ocean for detecting climate variability. Also methods are developed to monitor and adapt new sensors to algae blooms in the Baltic Sea.

The Numerical Weather Prediction group at SMHI is furthermore working with the utilisation of satellite data for weather forecasting models. At present this work is focused on satellite sounding information (ATOVS), on MODIS radiance data and on ground-based GPS data.

SMHI, Section for Research and Development, 601 76 Norrköping, Sweden

Contact persons: Sten Bergström, Nils Gustafsson, Bertil Håkansson

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 E-mail: Bertil.Hakansson@smhi.se, Sten.Bergstrom@smhi.se,
 Nils.Gustavsson@smhi.se,
<http://www.smhi.se>, <http://www.smhi.se/>

Radar Remote Sensing Group, Radio and Space Science, Chalmers University of Technology

The radar remote sensing group at Chalmers works with developing techniques for retrieve bio-geophysical parameters from synthetic aperture radar (SAR) images. In particular the focus is on understanding of the electromagnetic scattering and the properties of the imaging system.

Radio and Space Science, Chalmers, 412 96 Göteborg, Sweden

Contact person: Gary Smith

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Space Geodesy, Onsala Space Observatory, Chalmers University of Technology

We use space geodetic systems, such as GPS and VLBI, to remotely sense the water vapour content of the atmosphere, the total electron content of the ionosphere, and to study crustal dynamics of the earth, e.g. the postglacial rebound in Scandinavia. Time series of water vapour from GPS are supplied to meteorological institutes for impact studies in weather forecasting and their long-term stability for climate monitoring is assessed. Dense ground-based GPS network are used together with tomographic methods to estimate the 3D structure of atmospheric water vapour.

Onsala Space Observatory, S-439 92 Onsala, Sweden

Contact person: Gunnar Elgered, Jan Johansson

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 E-mail: kge@oso.chalmers.se, jmj@oso.chalmers.se
<http://www.oso.chalmers.se/geo>

Department of Physical Geography and Ecosystems Analysis, Lund University

The research focuses on extraction of biophysical variables of land vegetation from optical satellite sensor data. Current projects study forest biomes in Sweden and semi-arid regions of Africa. Optical data from various sensor systems are used (Landsat/ETM, Terra/MODIS, SPOT/Vegetation, NOAA/AVHRR etc.).

Department of Physical Geography and Ecosystems Analysis, Lund University,
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Contact person: Lars Eklundh

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<http://www.natgeo.lu.se>

Atmospheric Research

Atmospheric Physics Research Programme, Swedish Institute of Space Physics in Kiruna

The programme studies the physical and chemical processes affecting the Arctic middle atmosphere, includes winds, waves and tides, clouds and aerosol particles, and stratospheric trace-gases.

Swedish Institute of Space Physics, Box 812, S-981 28 Kiruna, Sweden

Contact person: Sheila Kirkwood

Phone: +46-980-79083, Fax: +46-980-79091

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<http://www.irf.se/MRIatmos/>

Department of Meteorology, Stockholm University

Experimental and theoretical studies of the structure and composition of the middle atmosphere

Department of Meteorology, Stockholm University, 106 91 Stockholm, Sweden

Contact person: Jacek Stegman

Phone: +46-8-16 24 08, Fax: +46-8-15 71 85

E-mail: jacek@misu.su.se

<http://www.misu.su.se/atmphy.htm>

Global Environmental Measurements Group, Radio and Space Science, Chalmers University of Technology

The Global environmental measurements group works to provide and help interpret global datasets of relevance to environmental questions.

Radio and Space Science, Chalmers, 412 96 Göteborg, Sweden

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<http://www.rss.chalmers.se/gem>

Space Physics

Solar System Physics and Astrophysics Research Programme, Swedish Institute of Space Physics in Kiruna

The programme is devoted to comparative research on the evolution and dynamics of the solar system objects (planets, asteroids, meteoroids) and their interaction with the solar wind. In 2002-2003 the activities in the programme were concentrated around development of instruments for the ESA missions Mars Express, Rosetta and Venus Express on which it has PI-level experiments, but there was also participation in the Chinese magnetospheric mission Double Star and the ESA mission SMART-1. The programme is also developing instruments for forthcoming missions such as ESA's Bepi Colombo. The programme also runs projects dedicated to simulations of plasma processes near the inner planets and ground-based radar studies of meteors and dust. The programme conducted research on generation of energetic neutral atoms at Mercury and Venus, modelling of the Mars solar wind interaction as well as analysis of the meteor mass distributions.

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<http://vega.irf.se/p3web/>

Solar Terrestrial Physics Research Programme, Swedish Institute of Space Physics in Kiruna

The programme focuses on understanding space plasma physics phenomena on the basis of measurements and modelling, and on predicting their effects on technological systems.

Swedish Institute of Space Physics, Box 812, S-981 28 Kiruna, Sweden

Contact person: Rickard Lundin

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<http://www.irf.se/p2/>

Space Plasma Physics Research Programme, Swedish Institute of Space Physics in Uppsala

The programme explores the plasma universe. Data from our instruments on spacecraft are used to understand and model space plasma processes. Our main satellite projects are the four Cluster satellites (Earth orbit), Cassini (Jupiter and Titan) and Rosetta (Comet 67P/Churyumov-Gerasimenko). One major activity is to study the coupled magnetosphere-ionosphere system and its interaction with the solar wind and the upper atmosphere by combining in situ multi-satellite (Cluster) observations of small-scale processes at the various magnetospheric boundaries with observations of large-scale processes using ground-based facilities such as EISCAT.

Swedish Institute of Space Physics, Box 537, S-751 21 Uppsala, Sweden

Contact person: Mats André

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Physics in Space Research Programme, Swedish Institute of Space Physics in Uppsala

The focus of the programme is on studying fundamental physical processes in space by using space as a physics laboratory.

Swedish Institute of Space Physics, Box 537, S-751 21 Uppsala, Sweden

Contact person: Bo Thidé

Phone: +46-18-471 5914, Fax: +46-18-471 5905
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Space Plasma Group, Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH)

The research aims at a better understanding of plasma phenomena associated with the solar wind interaction with the magnetosphere and ionosphere of the Earth and of other planets. Space experiments are carried out in various space plasma regions by means of satellites and space probes. The analysis and interpretation of the experimental data are often done in parallel with numerical simulations to reveal the physics of the explored phenomena. At present we participate on experiments on Cluster in Earth orbit, on SMART-1 on its way to the Moon, and on Rosetta, to be launched to comet 67P/Churyumov-Gerasimenko in spring 2004.

Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH), S-100 44 Stockholm, Sweden.

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Laboratory Plasma Group, Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH)

The group makes laboratory plasma experiments and simulations ranging from applied plasma physics to phenomena of space relevance. Central fields are dusty plasma physics in microgravity, the interaction between plasmas in motion and magnetic field barriers (e.g. the magnetopause), and diagnostics and modelling of the VASIMR plasma rocket prototype engine.

Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH), S-100 44 Stockholm, Sweden.

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Swedish Institute of Space Physics in Lund

The group focuses on exploration and modelling of the physical processes behind solar magnetic activity using knowledge-based neural networks, wavelet methods, dynamo and helioseismological theory. In addition it studies the solar-climate coupling, it studies and forecasts the effects of space weather on technological systems within ESA projects, it runs the Regional Warning Center (RWC-Sweden) within the International Space Environment Service (ISES) and it archives Space Weather Euro News (SWEN).

Swedish Institute of Space Physics, Scheelevägen 17, S-223 70 Lund, Sweden.

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Astronomy & Astroparticle Physics

Extragalactic Group, Uppsala Astronomical Observatory

Galaxy formation and evolution.

Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden

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 E-mail: nils.bergvall@astro.uu.se
<http://www.astro.uu.se/galaxies/>

Stellar Atmospheres Group, Uppsala Astronomical Observatory

Studies of Stellar Atmospheres

Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden

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Phone: +46-18-471 59 57, Fax: +46-18-471 59 99
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<http://www.astro.uu.se/atmos/>

Planetary System Group, Uppsala Astronomical Observatory

Studies of Small Bodies in the Solar System

Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden

Contact persons: Hans Rickman, Claes-Ingvar Lagerkvist

Phone: +46-18-471 59 71, Fax: +46-18-471 59 99
 E-mail: Hans.Rickman@astro.uu.se
<http://www.astro.uu.se/planet/>

Astroparticle Physics, Royal Institute of Technology (KTH)

Research in astroparticle physics. Measurement of the flux of cosmic antimatter with balloon and satellite experiments CAPRICE and PAMELA, measurement of cosmic gamma-rays with satellite project GLAST. Design of gamma-ray polarization experiment POGO.

KTH Physics Department, AlbaNova, S-10691 STOCKHOLM, Sweden

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<http://www.particle.kth.se>

Infrared Group, Stockholm Observatory

The research group is actively participating in national and international space experiments with instruments for observations in the infrared and sub-mm spectral regions including ISO (now only data analyses), Odin (scheduling, data reduction and analyses), Herschel (instrument simulator for SPIRE and preparations for the scientific programmes), JWST (providing filters and beamsplitters for the mid-IR camera/spectrometer, MIRI) and Darwin (preparations, including coordination work with the NASA corresponding experiment, TPF).

Stockholm Observatory, AlbaNova, S-106 91 Stockholm, Sweden

Contact person: Göran Olofsson, René Liseau

Phone: +46-8-5537 8524, Fax: +46-8-5537 8510
 E-mail: olofsson@astro.su.se
<http://www.astro.su.se/English/groups/infrared/ir.html>

AGB stars and planetary nebulae, Stockholm Observatory

The research centres on the mass loss of AGB stars, and its effect on stellar and galactic chemical evolution. The programme is mainly observational and uses a multi-wavelength and multi-method approach. Space-borne activities are molecular line observations with Odin, and Herschel/HIFI preparatory work.

Stockholm Observatory, AlbaNova, S-106 91 Stockholm, Sweden

Contact person: Hans Olofsson

Phone: +46-8-55 37 85 16: Fax: +46-8-55 37 85 10
 E-mail: hans@astro.su.se
<http://www.astro.su.se/English/groups/latestages/agbnp/index.html>

High Energy Astrophysics, Stockholm Observatory

Research on compact objects in various fields of high energy astrophysics. Members of instrument teams for the Integral and GLAST gamma-ray missions.

AlbaNova University Center, Stockholm Observatory, S-106 91 Stockholm, Sweden

Contact persons: Stefan Larsson, Felix Ryde

Phone: +46-8-5537 8543, Fax: +46-8-5537 8510
 E-mail: svensson@astro.su.se
<http://www.astro.su.se/Xgamma>

Galaxy Group, Stockholm Observatory

Galaxy evolution as viewed with the Hubble Space Telescope.

Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden

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Phone: +46-8-5537 8513, Fax: +46-8-5537 8510
 E-mail: ostlin@astro.su.se
<http://www.astro.su.se/English/groups/galactic/galaxy.html>

Observational Cosmology at Stockholm Observatory

Supernovae

Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden

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<http://www.astro.su.se/~claes/obscosm.html>

Supernova Cosmology, Physics Department, Stockholm University

The use of Type Ia supernovae (SNe) as distance indicators has led to a major breakthrough in the measurements of the contents of the universe. HST has been very successfully used to follow-up very distant SNe discovered from the ground and perform accurate photometry and spectroscopy. ACS/HST is also used to search for very high-redshift SNe ($z > 1.2$).

The current HST activities provide very useful experience for the planned SNAP/JDEM satellite, for which our group has also done a large number of simulation studies, covering its science reach and expected systematic uncertainties.

Albanova University Center, S-106 91 Stockholm, Sweden

Contact person: Ariel Goobar

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E-mail: ariel@physto.se

<http://www.physto.se/~ariel>

GARD OSO, Chalmers University of Technology

The ESA project "Herschel Space Observatory" is a radio astronomical satellite that will perform photometric and spectroscopic observations in the 60-670 μm wavelength range.

One of the instruments is the Heterodyne Instrument (HIFI) for high-resolution spectroscopy. The instrument is built on a modular principle: the mixers together with their respective optic components are integrated in Mixer Sub-Assemblies (MSA). The Group for Advanced Receiver Development, GARD, has designed and built a Gaussian Beam Measurement Range to provide scalar measurements for the MSA beams to achieve ultimate optical coupling of the HIFI frontends with the antenna. This system can be used to provide measurements between 400-1100 GHz.

GARD MC2, Chalmers University, S-412 96, Gothenburg, Sweden

Contact person: V Belitsky

Phone: +46-31-772 1000: Fax: +46-31-772 1801

E-mail: belitsky@oso.chalmers.se

<http://gard04.mc2.chalmers.se/Rymdstyrelsen/overview.html>

Bolometer Group, Chalmers University

Development of attowatt terahertz bolometers for post-Herschel space telescopes. The ultimate performance of the cold-electron bolometers is determined by an electron cooling, SQUID femtoamperemeter, and a novel quasiparticle amplifier. The large scale arrays with multiplexing readout will be developed in scope of the ESA-led Consortium.

Department of Microtechnology and Nanoscience, Chalmers University of Technology, S-41296 Gothenburg, Sweden

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 e-mail: leonid.kuzmin@mc2.chalmers.se
<http://fy.chalmers.se/assp/BOLO/>

Odin Astronomy and Odin Data Processing at Onsala Space Observatory

Odin astronomers at Onsala Space observatory are deeply involved in the analysis Odin's sub-millimetre spectroscopy observations of H₂O, H₂¹⁸O, H₂¹⁷O, NH₃, ¹⁵NH₃, CO, ¹³CO, and C¹⁸O in interstellar molecular clouds and in the simultaneous searches for molecular oxygen. Another area of interest is searches for new interstellar molecules. All mm/submm astronomy and astronomy data is pipeline processed at the Odin Data Centre at Onsala, managed by Michael Olberg.

Centre for Astrophysics and Space Science at Chalmers University of Technology, Onsala Space Observatory, S-439 92 Onsala, Sweden

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<http://www.oso.chalmers.se/oso/odin/index.html>

Atomic Astrophysics, Lund Observatory

Astrophysical programs on spectroscopy

Lund Observatory, Box 43, SE-221 00 Lund, Sweden

Contact person: Sveneric Johansson

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 E-mail: sveneric.johansson@astro.lu.se
<http://www.astro.lu.se/atomic/>

Stellar Astrometry & Galactic Research at Lund Observatory

Astrophysical space research using Hipparcos and GAIA.

Lund Observatory, Box 43, SE-221 00 Lund, Sweden

Contact person: Lennart Lindegren

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 E-mail: lennart@astro.lu.se
<http://www.astro.lu.se/~lennart/Astrometry/>

Astrobiology

Department of Palaeozoology, Swedish Museum of Natural History

Microanalysis of Microfossils on Earth – Preparation for Ancient Earth studies and for Sample return from Mars

Department of Paleozoology, Swedish Museum of Natural History, Box 50007, 104 05 Stockholm, Sweden

Contact persons: Tomas Hode, Stefan Bengtson

Phone: +46-8-5195 4169, Fax: +46-8-5195 4184

E-mail: tomas.hode@nrm.se

http://www.nrm.se/pz/re_tomash.html.en

Department of Geology and Geochemistry, Stockholm University

Synthesis and characterisation of peptides encoded by self-assembled monolayers on nucleic acid bases absorbed on mineral surfaces: Relevance to pre-RNA information processing and the origins of life.

Stockholm University, Department of Geology and Geochemistry, SE-106 91 Stockholm, Sweden (also Örebro University, Department of Natural Sciences, MTM Research Center, SE-701 82 Örebro, Sweden)

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Human Spaceflight

Section for Environmental Physiology, Karolinska Institutet

Pulmonary and Cardiovascular Effects of Gravity and Weightlessness

Department of Physiology and Pharmacology, Karolinska Institutet, S-171 77
Stockholm, Sweden

Contact person: Dag Linnarsson

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Section for Exercise Physiology, Karolinska Institutet

Exercise Prescriptions for Astronauts

Section for Exercise Physiology, Department of Physiology and Pharmacology,
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E-mail: Per.Tesch@fyfa.ki.se
<http://www.fyfa.ki.se/>

Department of Physics, Royal Institute of Technology (KTH)

Dose Estimation by Simulation of the ISS Radiation Environment (DESIRE). Using the GEANT4 package supported by CERN the dose in space vehicles will be estimated. The GEANT4 results will be compared with other simulation packages and transport code calculations.

Department of Physics, Royal Institute of Technology (KTH), SCFAB, 106 91
Stockholm, Sweden

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Phone: +46-8-55378179, Fax: +46-8-55378216
E-mail: christer.fuglesang1@jsc.nasa.gov
<http://www.particle.kth.se/>

Architecture and Development Studies, Lund Institute of Technology

The STAR Design studio (Space and Terrestrial Architectural Research Design) studies pre-industrial habitats in Africa and South East Asia, and develops design concepts for future habitats in space and on the planet Mars. Since 1997 design studios have been set up with NASA/Johnson Space Center, Houston, Texas. The department has research focussing on space and terra applications.

Division of Architecture and Development Studies, Lund Institute of Technology,
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marcus@voneuler.org
<http://www.ark3.lth.se>

Material Sciences in Microgravity

Department of Engineering, Physics and Mathematics, Mid Sweden University

Solidification and crystal growth experiments are done to study the influence of convection on the distribution of alloy elements or dopants in grown materials. Especially the coupling between weak convection and radial segregation is investigated. Currently experiments are prepared to be performed on the International Space Station.

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YKI Institute for Surface Chemistry

Studies of foaming and de-foaming mechanisms under microgravity.

YKI Institute for Surface Chemistry, Box 5607, S-114 86 Stockholm, Sweden

Contact person: **Bengt Kronberg**

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<http://www.surfchem.kth.se/yki/web/research/indexcei.html>

Department of Materials Science and Engineering, Royal Institute of Technology (KTH)

Thermophysical properties of silicate melts, are measured under 1 g and the results are compared with electrostatic levitation (ESL) measurements under microgravity.

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Space Technology

Space Technology, Swedish Institute of Space Physics

Satellite instruments and subsystems, nanosatellites, space environment impact, flight control software.

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The Ångström Space Technology Center, Uppsala University

Micro System Technology for space applications. The technical research is focused on high performance nano satellites and future planetary exploration probes.

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Department of Microelectronics, Chalmers University of Technology

Superconducting THz Mixers for the Herschel Payload Based on NbN Hot-Electron Devices. Using Extremely Low Noise Microwave IF Amplifiers Based on In-House HEMT Transistors.

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