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Swedish Institute of Space Physics—Research Strategies

The Swedish Institute of Space Physics (IRF) is a national research institute under the auspices of the Swedish Ministry of Education and Research. Research at IRF is currently conducted within four research programmes. IRF also has an observatory programme and carries out observatory activities in the fields of space and atmospheric physics. This document summarizes the objectives, success factors and goals of IRF as a whole and of the individual programmes.

Objectives

IRF's objectives are to:

- Conduct research in the fields of space- and atmospheric physics.
- Contribute to development in space technology.
- Play an important role in research education in these three fields.
- Focus on experimental research in these fields.
- Continue as a node in the global network of geophysical observatories.
- Promote the intellectual development of its employees.

Success factors

Successful scientific research and continued support from decision makers require that IRF:

- Conducts research of the highest international standard.
- Acts as a national and international network organisation.
- Has a strong connection with universities, other research organisations, industry and society.
- Stands for good leadership, exciting work opportunities, a creative atmosphere and intellectual challenges.
- Takes advantage of Sweden's geophysical location and the Arctic environment.
- Remains a flexible and efficient research organisation.

Goals

The long-term goals for IRF (5-10 years) are to:

- Be recognised as one of the top experimental space- and atmospheric physics organisations in Europe.
- Remain one of the most successful European competitors by being chosen as Principal Investigator (PI) on major missions.
- Strengthen its role as a partner in EU projects and with the Swedish and European space industries.
- Establish itself as a natural research link for students at Swedish and European universities.
- Play a major role in the graduation of on average 1-3 PhD students per year.
- Be recognised as a provider of reliable scientific data.
- Maintain successful research programmes with individual profiles and an overall average of 50% external funding.

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Polar Atmospheric Research Programme

The programme conducts research into processes affecting the polar atmosphere, including dynamical and chemical processes in the mesosphere, stratosphere and troposphere. Research is primarily based on the use of IRF's ground-based remote sensing instruments complemented by in-situ measurements using balloon-borne sensors. Atmospheric models and further observations, both ground- and satellite-based, are utilised through national and international collaboration, including the international radar facility EISCAT.

Objectives

The objectives of the programme are to:

- Improve understanding of the physical and chemical processes affecting the Arctic and Antarctic troposphere, stratosphere and mesosphere.
- Contribute to global change research by long-term monitoring and process-oriented research related to the stratospheric ozone layer and to polar mesospheric clouds.
- Contribute to global change research by studies into the ways in which processes in the stratosphere and above contribute to conditions at the Earth's surface.

Success factors

The programme is known and respected for:

- Research on the full height scale of the high-latitude atmosphere including both neutral and plasma states — from the Earth's surface to the aurora.
- National and international collaboration, contributing unique observations by ground-based remote sensing in the Arctic and Antarctic.
- Contributing observations to international networks aiming for pan-European and global monitoring of the atmosphere.

Goals

The long-term goals of the programme (5-10 years) are to:

- Provide calibrated measurements of key atmospheric parameters which can be used in future detection and attribution of atmospheric changes in the polar regions.
- Contribute to better understanding of the role of vertical exchange in the atmosphere in determining conditions at the Earth's surface in the polar regions.
- Be recognized nationally and internationally as an important scientific contributor to research on the polar atmosphere.

The short-term goals of the programme (2-3 years) are to:

- Publish data summaries on IRF web server for all observations since 1996.
- Continue to operate the atmospheric radar MARA at Maitri, Antarctica, and secure high-quality measurements covering at least 24 months.
- Replace ageing hardware in the ESRAD radar to allow continued operation.
- Ensure that any future EISCAT 3D system is capable of atmospheric measurements.
- Continue operation and achieve NDACC certification of the KIMRA and MIRA2 mm-wave radiometers.
- Maintain the rate of first-author refereed publications at $\geq$ 4 per year.
- Establish new collaborations for applied research.

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Solar Terrestrial Physics Research Programme

The programme conducts research into aspects of the sun, the solar corona, the solar wind, and the near-Earth space environment, including space weather and meteor research. It is also involved in applications related to space weather and effects on technological systems.

Objectives

The objectives of the programme are to:

- Improve our understanding of basic space plasma physics phenomena in the solar-terrestrial environment, with focus on problems related with the variable sun and its influence on the Earth: its atmosphere, ionosphere and magnetosphere.
- Improve our understanding of the solar variability and how that affects the Earth, human society, technological systems and the climate.
- Communicate our knowledge about solar-terrestrial relations to Swedish society.
- Study dynamical processes and structure formation associated with natural and anthropogenic perturbations of geospace, including electromagnetic radiation phenomena.
- Develop new analysis methods and sensor networks for studies using optical, radar, and infrasound recordings.

Success factors

The programme has the following current strengths:

- World-class reputation in space plasma physics research and leadership of space projects.
- Excellence in developing new data analysis- and advanced forecasting methods.
- Excellence in radar and optical research of ionospheric- and magnetospheric phenomena.
- An advantageous geographical location combined with long-term observations of solar-terrestrial phenomena (aurora, magnetic disturbances etc).
- Benefit from contacts with media, science centres and museums to enhance public outreach activities.

Goals

The long-term goals of the programme (5-10 years) are to:

- Be recognized and respected in the worldwide science community as a research programme providing major contributions in: solar physics and space weather; magnetospheric and ionospheric dynamics; and studies of optical aurora and the upper atmosphere.
- Achievement of these goals requires a broad international collaboration, a creative research environment and advanced data analysis tools applied to ground- and space-based scientific data.
- Support the establishment of the EISCAT_3D.

The short-term goals of the programme (2-3 years) are to:

- Establish new contacts with a focus on optical aurora, other upper atmospheric phenomena, and the solar activity.
- Publish high-quality scientific papers at a continued high rate (about one first-author paper per scientist and year) based on satellite- and ground-based data.
- Secure funding for the EISCAT_3D radar, for upgrade of ALIS and for the extension of the infrasound network.
- Prepare for a mission to study the difference between N^+ and O^+ ions in space.
- Define the role of IRF concerning space weather forecasting in Sweden.

Solar System Physics and Space Technology Research Programme

The programme conducts research on the interaction of solar and stellar winds with the environments of planets, moons, asteroids and comets.

Objectives

The objectives of the programme are to:

- Study the environment (plasma and neutral gas) and the solar wind interaction as well as the evolution and dynamics of solar system objects – planets, moons, asteroids, comets and dust.
- Develop scientific instrumentation for satellite-based measurements of particles in support of space science and solar system exploration.
- Develop new numerical models and data analysis methods in the field of space science.
- Participate in space-related educational programs and public outreach activities.

Success factors

- Leading European group in the field of experimental space plasma physics with focus on particle measurements.
- Wide international contact net and excellence in managing experiments for national, international and bilateral space missions.
- Excellence in designing and manufacturing world-class instrumentation for in-situ measurements of ions, electrons and energetic atoms in space.
- Excellence in analysing and interpreting data plus numerical modelling of space plasmas.
- Flexibility in research planning and the ability to develop expertise in new areas of research related to the programme topics.
- Highly professional and experienced engineering and scientific staff.
- Availability of unique calibration and manufacturing facilities.

Goals

Long-term goals of the programme (5-10 years) are to:

- Remain the European leader in the field of solar system space physics
- Complete a “grand tour” of the inner planets for comparative magnetospheric studies and to achieve a deep understanding of solar wind interaction physics including plasma-surface interactions.
- Advance research in the field of space environments of the giant planets and comets.
- Continue development of compact ion mass analysers and reach a mass resolution of a few tens (CNO group separation) and angular resolution around 5° x 5°.
- Reach angular resolution of ENA imagers for a few tens of eV to a few keV range down to 5°.
- Establish a world-class calibration and test facility for space particle instrument development (SpaceLab).

Short-term goals of the programme (2-3 years) are to:

- Continue modelling solar wind/magnetosphere interactions with the moon, Mars, Venus and Jupiter’s Galilean moons.
- Complete Chandrayaan-1 data analyses related to the solar wind/moon interaction.
- Use Mars- and Venus Express data to continue studies of the solar wind interaction with non-magnetized bodies.
- Develop and deliver instruments for the ESA/JAXA BepiColombo mission.
- Develop sensors for the ESA JUICE mission to Jupiter.
- Continue experimental research of the Mars and moon/solar wind interaction.
- Participate actively in planning of international and national missions.

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Space Plasma Physics Research Programme

The programme conducts research into magnetospheres and dynamic processes in space plasma.

Objectives

The objectives of the programme are to:

- Explore the plasma universe by means of in-situ and ground-based observations.
- Understand and model plasma phenomena in the universe.
- Promote space technology and space science.
- Participate in teaching, in particular of space physics and space technology.
- Contribute to public outreach activities.

Success factors

The programme is known and respected for or as:

- A world-class space plasma physics team.
- In-situ observations by spacecraft of DC and wave E-fields as well as of plasma density and temperature (including multi-probe, multi-spacecraft techniques).
- Experience of planning, engineering, management and operations on several Swedish and international missions.
- Experience of detailed data analysis, validation and comparison with theory.
- Software for data analysis and distribution.

Goals

The long-term goals of the programme (5-10 years) are to:

- Remain a top space plasma physics team for instrumentation, observations and modelling.
- Achieve understanding of micro-plasma physics of importance for large-scale physics (turbulence, transport and particle acceleration associated with boundaries) obtained by comparing different space plasmas.
- Develop new and improved scientific instruments to achieve these scientific goals, and fly these on Swedish and international missions.
- Be an important partner for the space industry and Uppsala University with respect to space technology.
- Participate in teaching at Uppsala University.
- Contribute to public outreach.

Short-term goals of the programme (2-3 years) are to:

- Use Cluster and EISCAT to explore the dynamics and structure of the electric fields in boundaries.
- Use Cassini to explore the dynamics of the ionosphere of Titan, and the rings of Saturn and their similarities to astrophysical discs.
- Bring on-going satellite missions to completion: Cluster, Cassini, Swarm and Rosetta.
- Bring on-going scientific hardware projects to completion: BepiColombo and MMS.
- Develop instrumentation for the ESA missions Solar Orbiter and JUICE.
- Participate actively in national and international planning of future missions.
- Participate in planning EISCAT operations.
- Collaborate on engineering and development with Uppsala University, KTH and ÅAC Microtec.
- Take major responsibility for three courses at Uppsala University.
- Publish an average of one first-author paper per scientist each year.

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Observatory Programme

The Swedish Institute of Space Physics has a national responsibility to perform long-term monitoring (collect observatory data) in the field of atmospheric and space plasma physics; this is done within the Observatory Programme. The main data series have been collected since the 1950s (and some even earlier) and are provided by magnetometers (Kiruna and Lycksele), riometers (Kiruna and Lycksele), all-sky camera (Kiruna) and ionosondes (Kiruna, Lycksele and Uppsala).

Objectives

The objective of the Observatory Programme is to:

- Perform long-term monitoring in the field of geophysics and to archive and make these long time series available to future generations of scientists.

A secondary objective is to:

- Provide scientists and the general public with fast and simple access to both archived and real-time data.

Success factors

The programme will focus on the following success factors:

- Long-term aspects (stability, durability over 100 years or more).
- Highest possible scientific quality of the collected data.
- International cooperation (standards, methods, quality assurance).

Goals

The long-term goals of the programme are to:

- Ensure that a continuous time series of long-term monitoring data of the highest possible scientific quality is securely archived and made available via the IRF web server.
- Demonstrate whether or not there have been long-term changes in the collected data by participating in scientific studies and by publishing the results.
- Invest in a new ionosonde in Lycksele.

The short-term goals of the programme (2-3 years) are to:

- Strengthen the connection between the observatory programme and related scientific research at IRF as well as elsewhere.
- Evaluate new candidate instruments and time series to be included in the observatory's long-term monitoring programme.
- Continuously work on improving the quality of the observations and initiate external evaluations of the observatory activities.
- Ensure all archived data is digitized and readily available via the IRF web server.
- Install new ionosondes in Kiruna and Uppsala.