Swedish Institute of Space Physics, IRF—Research Strategies

The Swedish Institute of Space Physics, IRF, is a national research institute under the auspices of the Swedish Ministry of Education. Research is currently carried out in five research and one observatory programme. The objectives, success factors, long-term and short-term goals of IRF as a whole and of each programme are summarized in this document.

Objectives:
IRF's objectives are to:
• Conduct basic research and contribute to research education in the fields of space physics, atmospheric physics and space technology,
• Focus on experimental research, in situ as well as from the ground,
• Continue as a node in the global network of observatories,
• Actively support the development of new technologies, for research as well as for utilisation in society,
• Promote science and technology for the benefit of Swedish society by making its research and technology available,
• Actively promote opportunities for, and the intellectual development of, its employees.

Success factors:
Successful scientific research and appreciation by decision makers in our society require that:
• The research at IRF is of the highest international standard,
• IRF acts as a national and international network organisation within the space sciences,
• IRF has a strong connection with universities, industry and society,
• IRF stands for good leadership, exciting work opportunities, a creative atmosphere and intellectual challenges,
• IRF takes advantage of Sweden's favourable geophysical location.

Goals
The long-term goals for IRF (5-10 years) are to have:
• Maintained its role as one of the top experimental space physics groups in Europe,
• Remained one of the most successful European competitors for PI-ships in major missions,
• Strengthened its role as an innovation partner within the Swedish and European space industries,
• Established itself as a natural research link for students at Swedish and European Universities, playing a major role in the graduation of 3-5 PhD students per year,
• Become a leading partner in emerging sensor network projects in space and atmospheric physics.

The short-term goals for IRF (2-3 years) are to have:
• Five research programmes with individual profiles in successful operation with an overall average of 50% external support,
• Acquired PI-involvement in at least two major international projects,
• Identified resources to (1) maintain and enhance ground-based research activities, and (2) update the already existing Swedish observatory network,
• Achieved a successful international continuation and improvement of the EISCAT facilities beyond 2006.

Atmospheric Physics Research Programme

The programme conducts experimental research into processes affecting the Arctic middle-atmosphere, which includes the cold polar vortex of the dark stratospheric winter and the even colder, permanently daylit mesopause of summer.

Objectives:
The objectives of the programme are to:
• Improve understanding of the physical and chemical processes affecting the Arctic middle-atmosphere,
• Improve the education of space technologists (and other students in Kiruna) so as to give them a better understanding of atmospheric processes and of the technology used to study the atmosphere,
• Assist the community in attracting both visitors and new residents to Kiruna.

Success factors:
The programme is known and respected for:
• Research topics where our location is an advantage: aspects of the physics and chemistry of the middle atmosphere which are specific to the Arctic and which can be studied better by longer-term observations than by occasional, short campaigns,
• Complementing Swedish and international observations (from sounding rockets, aircraft, balloons and remote-sensing satellites) with observations by ground-based remote sensing from Kiruna and our own space-based observations,
• Contributing our observations to international networks aiming for pan-European or global atmospheric monitoring.

Goals:
The long-term goals of the programme (5-10 years) are to:
• Investigate as yet unknown connections between the various atmospheric processes and monitor the future development of these processes,
• Contribute to two of the activities being encouraged by the Kiruna community, space and environmental research, and increased tourism.

The short-term goals of the programme (2-3 years) are to:
• Publish further studies of a number of atmospheric processes newly identified by our group: plantary-wave influences in the summer mesosphere, aerosol layers in the winter mesosphere, and effects of electron heating on dusty plasma at the mesopause,
• Estimate in-vortex winter ozone loss each year and quantify the influence of wave activity on the winter ozone chemistry,
• Complete construction of the new aerosol/ozone lidar,
• Maintain our contributions to international atmospheric databases at at least the present level,
• Establish a better co-operation with the universities of Umeå and Luleå with regard to both teaching and research at the Kiruna Space and Environment Campus (KRM).

Solar Terrestrial Physics Research Programme

The programme conducts research into aspects of the sun, the solar corona and the space environment, including the solar wind's interaction with satellites, the Earth and its magnetosphere.

Objectives:
The objecitives 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 long-term 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.

Success factors:
The programme will focus on the following current strengths:
• A world-class reputation in space plasma physics research using experimental-, simulation-, and forecasting techniques,
• Excellence in the design and testing of instrumentation for space plasma studies,
• Excellence in the development of new data analysis tools and advanced prediction tools for space weather forecasting,
• Our role as an active educational partner to KRM and Lund University,
• Our advantageous geographical location within the auroral oval.

Goals:
The long-term goals of the programme (5-10 years) are to:
• Be one of the leading groups of scientists working with solar-terrestrial coupling issues,
• Contribute significantly to certain critical issues in solar physics (such as the solar magnetic activity) and in magnetospheric physics (such as the dominating process responsible for the transfer of energy through the magnetopause),
• Develop a widely-used forecast model of the solar activity influence on the terrestrial environment,
• Develop a model for the non-thermal escape of volatiles from the Earth,
• Contribute significantly to the understanding of the auroral processes.

The short-term goals of the programme (2-3 years) are to:
• Perform an ESA space weather pilot project (financed by ESA/ESTEC),
• Be recognised as one of the leading Regional Warning Centers through developing space weather forecast tools and studying spacecraft-plasma interactions,
• Participate in or manage a project funded by the EU 6th Framework Programme,
• Increase our participation in Cluster data analysis work,
• Produce scientific reports using the EISCAT radar in collaboration with, e.g., Oulu University and NIPR,
• Establish an improved international collaboration related to the use of ALIS and have ALIS in operation,
• Have well-established working links with KRM, the Graduate School of Space Technology and Lund University.

Solar System Physics and Space Technology Research Programme

The programme conducts research into aspects of the interaction of the solar wind with planets, asteroids and comets, their atmospheres and magnetospheres, as well as researching magnetospheres round other astrophysical objects (stars and galaxies).

Objectives:
The objectives of the programme are to:
• Study the evolution and dynamics of the solar system objects (the inner planets, moons, asteroids, meteoroids, dust), their plasma environment and interaction with the solar wind,
• Maintain and further develop the national experimental competence in space technology and space instrumentation,
• Develop competence in numerical and data analysis and methods in the field of space science,
• Participate in university education and support the community through economic and PR programmes.

Success factors:
The programme will concentrate on the following current strengths:
• 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 atoms in space,
• Excellence in radar meteor research,
• Competence in analyzing and interpretation of data,
• Capabilities to develop new numerical models and analysis methods,
• Flexibility in research planing and, respectively, capabilities to develop expertise in new areas of research related to the program topic,
• Highly professional and experienced engineering and scientific staff,
• Teaching experience applicable for education on all levels,
• High PR potential of the program subject solar system exploration.

Goals
Long-term goals of the programme (5-10 years) are to:
• Cement a position as one of the top scientific groups in the world in the area of space instrumentation with continued participation in interplanetary and magnetospheric missions,
• Carry out PI-level experiments on at least in two large-scale missions,
• Complete a “grand tour” (of all inner planets) for comparative magnetospheric studies of the terrestrial planets,
• Establish the High Power Large Aperture (HPLA) radar application as a method for studying astronomical dust and meteor impact on the near-Earth space environment,
• Establish expertise in dust plasma research and astrobiological applications,
• Conduct at least 2-3 international conferences or workshops in Kiruna.

Short-term goals of the programme (2-3 years) are to:
• Participate in current missions and ground-based meteor radar studies,
• Use data from our instruments to explore processes of the ion outflow from Mars,
• Develop instruments for the ESA Venus Express mission and Bepi Colombo,
• Significantly improve the characteristics of the present plasma instruments,
• Perform feasibility studies of new measurement techniques such as ENA mass

spectroscopy, space dust plasma detectors, X-ray detectors,
• Develop simulation techniques relevant for research topics such as ENA, X-ray, dust imaging, solar wind Venus, Mars, Mercury interaction,
• Contribute to courses in space and solar system physics, technology and environment studies within the programmes of Umeå and Luleå universities as well as the Graduate School in Space technology,
• Establish regular media coverage of the programme's activities,
• Maintain the programme's web site including popular science sections.

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 the plasma 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:
• In-situ observations by spacecraft of DC and wave E-fields, and plasma density and temperature (including multi-probe, multi-spacecraft techniques),
• Planning, engineering, management and operations experience on several Swedish and ESA/NASA missions,
• Experience of detailed data validation, analysis and comparison with theory.
• Software for data analysis and distribution,
• World-class space plasma physics team.

Goals:
The long-term goals of the programme (5-10 years) are to:
• Compare microphysical processes in different space plasmas (Earth, ionosphere of Titan, a comet, Mercury, the solar corona) to achieve understanding of processes related to thin layers (bowshock, magnetopause) and of particle heating and acceleration (auroral acceleration, ionospheric outflow),
• Participate in the space engineering programme at Uppsala University,
• Be an important partner for ÅSTC with respect to miniaturisation etc.,
• Participate in terrestrial and extra-terrestrial space missions for in-situ observations of the plasma universe, including ESA/NASA missions.

Short-term goals of the programme (2-3 years and on-going missions) are to:
• Use Cluster and EISCAT to explore the 3D structure and time evolution of microphysical processes in the terrestrial magnetosphere, and their importance for large scale processes,
• Remain a top space plasma physics group (instrumentation, observations and modelling),
• Bring on-going missions to completion: Cluster, Cassini and Rosetta,
• Participate actively in national and international (ESA/NASA) planning of future missions,
• Participate in planning of EISCAT operations,
• Plan/build hardware for 2-4 missions (including technical tests),
• Collaborate on engineering and development together with ÅSTC and KTH,
• Take major responsibility for four courses in the space engineering programme at Uppsala University,
• Publish on average one first-author paper per scientist and year,
• Contribute to Public Outreach.

Physics in Space Research Programme

The programme studies the principles and mechanisms which control Earth's interaction with its space habitat by using the near-space environment of the Earth as a large outdoor laboratory without walls to conduct research into fundamental physical processes in space.

Objectives:
The objectives of the programme are to:
• Study dynamical processes and structure formation associated with natural and anthropogenic perturbations of geospace, including electromagnetic radiation phenomena,
• Study electrostatic and electromagnetic turbulence and the turbulent generation of large-scale flows both in situ and remotely,
• Develop and utilise computer codes for the efficient modelling, based on multi-dimensional fluid and kinetic theory, of the dynamics of structures in space,
• Develop new advanced methods and sensor networks for radiometric studies of geospace, from the upper atmosphere of the Earth up to the Sun.

Success factors:
The programme will:
• Benefit from synergies between the members of the programme, their combined expertise and competence, and the interdisciplinary networks they represent,
• Utilise its position as a leader in the development of novel space physics instrumentation and methodology,
• Use the holistic view and the physics competence furnished by programme members and collaborators to put space research on a firm physical basis,
• Benefit from excellent 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:
• Reach a deep understanding of the fundamental physics of geospace, in particular the non-linear dynamics, self-organisation and turbulence aspects,
• Establish ourselves as key players in science and technology within large transnational projects such as LOFAR and LOIS and the International Space Station,
• Become a world leader in instrumentation for wide-area time-coherent sensor networks for space studies from ground and space,
• Earn an international reputation as a first-class educator in space sciences and technologies.

The short-term goals of the programme (2-3 years) are to:
• Finalise the theory of SEE and associated phenomena so that this technique can be used at its full diagnostic power,
• Use the LOIS prototype and the upcoming PRISMA satellite to develop and utilise new radio methods for space physics and exploration,
• Obtain a thorough understanding of the physics which governs processes at transition layers in geospace,
• Complete the multi-dimensional simulation and visualisation tool-set under development so that it can be used as a routine tool for space physics phenomenology and modelling.

Observatory Programme

The main data series, which have been collected since the 1950's (some even earlier) 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:
• Provide society with as much information as possible about what is happening in the upper atmosphere and ionosphere over Sweden (under the constraints of available resources).

Success factors:
The programme will focus on the following success factors:
• International visibility (easily accessible web site),
• High technical quality of the observations,
• Long-term stability of the observations.

Goals:
The long-term goals of the programme (50 years) are to:
• Demonstrate whether or not there have been long-term changes in the atmospheric/ionospheric properties which we monitor.

The short-term goals of the programme (2-3 years) are to:
• Maintain an online service showing in real-time the state of auroral and other solar-induced activity (for scientists and the public),
• Increase use of the data to complement space-based or other instruments in scientific studies.