Appendices to Research overview 2023

Natural and engineering sciences

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1 Research infrastructures

1.1 Inventory of research infrastructures

Many Swedish scientists in the fields of natural and engineering sciences are, since several decades, and to an increasingly greater degree, using a variety of research infrastructures. Such infrastructures come in a variety of forms. Local or regional research infrastructures, often funded by a single university or a group of collaborating universities, serve local needs so as to provide users with faster and more convenient access to infrastructure that can well support many basic needs. National and international research infrastructures (of which some are distributed), often funded by national agencies or major research foundations, aim to provide advanced resources that enable research for a number of researchers (or research groups) and projects in specific research areas that in many cases could not have been realized or established by local or smaller constellations of users or research groups. The latter types of infrastructures, whereof the Swedish Research Council (VR) finances (or co-finances) a significant number, serve users in a variety of areas, e.g. in physics and engineering, life science, geophysics, material science, and environmental science. Some that are related to computational resources constitute E-infrastructures.

Examples of national and international research infrastructures of particular importance to the natural and engineering sciences in Sweden include (but are not limited to):

- ACTRIS (Aerosols, Clouds and Trace Gases Research Infrastructure), which is a distributed European research infrastructure that measures aerosols, clouds and reactive trace gases in the atmosphere – from the surface of the Earth to the stratosphere;
- ALMA (the Atacama Large Millimeter Array), which is an astronomical interferometer of a multitude of radio telescopes in the Atacama Desert of northern Chile that detects electromagnetic radiation at millimeter and submillimeter wavelengths;
- CERN (the European Organization for Nuclear Research), which is the largest particle physics laboratory for high-energy physics research in the world and which includes the Large Hadron Collider (LHC). At this facility, VR contributes to three experimental and one computations research infrastructure, Atlas, Alice, Isolde, and WLCG (the Worldwide LHC Computing Grid);
- DESIREE (Double ElectroStatic Ion Ring ExpEriment), which is a cryogenic ion-beam storage ring for atom-, molecule, and chemical physics in which ion-ion interactions in well-defined quantum states can be studied;
- EISCAT_3D (the European Incoherent Scatter Scientific Association), which is a radar system for the scientific study of the Earth’s atmosphere and ionosphere, including norther light, plasma physics, and atmospheric physics;

- EPOS (European Plate Observing System), which provides data about the solid ground (or “everything beneath our feet”);
- ESRF (the European Synchrotron Radiation Facility), which is a joint research synchrotron facility situated in Grenoble, France, at which research on protein crystallography, earth science, palaeontology, materials science, chemistry, and physics are pursued;
- Icebreaker Oden, which provides a research infrastructure with opportunities for multi-faceted studies of the atmosphere, ocean, cryosphere, marine ecosystems, and also the sediment and geology of ocean floors;
- ICOS (the Integrated Carbon Observation System), which is a distributed European infrastructure that measures and quantifies greenhouse gas uptake and emissions between land/water and atmosphere;
- IIL with Super-Adam, which is a facility for neutron scattering in France for research into fields such as materials and life sciences and chemistry. Sweden contributes to a neutron reflectometer, Super-Adam;
- IML (Institut Mittag-Leffler), which is an international centre for research and postdoctoral training in mathematical sciences whose mission is to support international top-level research in mathematics, with special attention to the development of mathematical research in Nordic countries;
- InfraVis (National Research Infrastructure for Data Visualization), which is a national research infrastructure for visualisation of data;
- Laserlab Sweden, which is a distributed research infrastructure comprising state-of-the-art laser instrumentation for research in the field of atomic, molecular and optical sciences;
- NBIS (National Bioinformatics Infrastructure Sweden), which is a distributed national bioinformatics infrastructure, supporting life sciences in Sweden;
- NGI (National Genomics Infrastructure), which is a national infrastructure for large-scale DNA sequencing and SNP genotyping
- NMI (National Microscopy Infrastructure), which provides access to instrumentation and competence within advanced microscopy);
- MAX IV, which is a national laboratory for accelerator physics and research by use of synchrotron light in fields such as materials science, biotechnology, medicine, energy and the environment;
- Myfab, which is a national research infrastructure, for research within fields such as materials science, nanoscience, information and communication technology, bio-nanotechnology, life sciences, energy research and micro-nanosystems and for micro and nano-fabrication;
- NordSIM-Vegacenter, which is a microanalytical facility at the Swedish Museum of Natural History that provides the Swedish Geoscience community with state-of-the-art microbeam analytical technology focused on in situ material analysis at the micron scale;
- Onsala Space Laboratory, which is a Swedish facility with telescopes and measuring instruments for radio astronomy and geodesy;
- PETRA, which is a German synchrotron light facility at the DESY laboratory outside Hamburg that focus on radiation in the X-ray area, for research in several scientific fields. Sweden funds the Swedish Material Science beamline, SMS, at Petra III;

- PSI (the Paul Scherrer Institute), which is a multi- disciplinary research institute that provides, on the same campus, all the four most important probes for researching the structure and dynamics of condensed matter (a synchrotron light source, a spallation neutron source, a muon source, and an X-ray free-electron laser);
- Riksriggen with IODP and ICDP, which is a drilling rig for scientific surveys of the Earth's crust, where IODP is an international programme for scientific drilling at sea while ICDP is the land-based equivalent;
- SBDI (the Swedish biodiversity data infrastructure), which is a portal for biodiversity data comprising information about populations of plants, animals and other life forms;
- SciLifeLab (Science for Life Laboratory), which is a national center for large-scale research within the fields of life sciences, molecular biosciences, computational biology, and bioinformatics with focus on health and environmental research;
- SITES (Swedish Infrastructure for Ecosystem Science), which is a distributed research infrastructure that coordinates a number (presently nine) of the country’s field stations for land-based climate, environmental and ecosystem research
- SNIC (the Swedish National Infrastructure for Computing), which is to be succeeded by NAIS (National Academic Infrastructure for Supercomputing), which is an infrastructure that makes available large-scale high-performance computing resources, storage capacity, and advanced user support; which offers national high performance computing (HPC) resources and data storage for academic research in Sweden
- SwedNMR (Swedish Nuclear Magnetic Resonance), which provides NMR instrumentation and expertise at six Swedish nodes into a national infrastructure where user support and instrument investments are coordinated at a national level within biomolecular NMR, materials NMR and translational NMR; and
- XFEL (the X-ray Free Electron Laser Facility), which is an European an X-ray free electron laser facility that generates intense X-ray flashes for research in a number of fields, including femtochemistry and molecular biology, that can be used to map atomic details of viruses, film chemical reactions, and study processes in the interior of planets;

Examples of research infrastructures that presently are under construction but that are expected to be of high importance for Swedish scientists in the close future include:

- ESS (the European Spallation Source), which is a is a multi-disciplinary research facility that will enable scientists to see and understand basic atomic structures and forces at length and time scales unachievable at other neutron sources useful for research in materials and life sciences, energy and environmental technology, among other things;
- FAIR (Facility for Antiproton and Ion Research), which is an accelerator facility for nuclear, hadron and ion physics, and
- SKA (the Square Kilometre Array), which is an international radio astronomy project that is being built in Australia and South Africa that will

operate over a wide range of frequencies and size that will make it 50 times more sensitive than any other radio instrument.

The wide breadth of national and international research infrastructures used by Swedish scientists does not only illustrate the great width of science being pursued in Sweden, it also emphasizes the importance of ensuring the continuous support and development of national and international research infrastructures.

2 Scientists involved in the research overview work

2.1 Questionnaire to project grant recipients

A questionnaire was sent to 1010 project grant recipients for the years 2018-2021. The response rate was 46 percent.

Questions

1. Please define your research area. Select the area that best represents your research from the predefined list.
2. What scientific advances during the last ten years do you regard as most important within your research area, both nationally and internationally?
3. What long-term scientific questions are central to your research area?
4. Looking ten years ahead: what major scientific breakthroughs do you foresee in your research area?
5. What are the main structural challenges within the Swedish research system (university structure, recruitment, funding system, etc.) that your research area is facing?
6. What research infrastructure needs do you anticipate for your research area in the coming decade?

2.2 Reference group and adjunct members

Working group	Name	Organisation
Biology	Rosa Fernandez	Centre for Genomic Regulation, Barcelona
	Per Hammarström	Linköping University
	Martin Ott	Stockholm University
	Elisabeth Sauer-Eriksson	Umeå University
	Åsa Strand	Umeå University
	Tobias Uller	Lund University

	Dominic Wright	Linköping University
Adjunct members	Alexandre Antonelli	Kew gardens
	Erik Lindahl	Stockholm University
	Sören Nylin	Stockholm University
	Martin Ott	Stockholm University
Chemistry	Fredrik Almqvist	Umeå University
	Aji Mathew	Stockholm University
	Nicole Pamme	Stockholm University
	Daniel Topgaard	Lund University
	Ola Wendt	Lund University
	Per-Olof Åstrand	NTNU Norwegian University of Science and Technology
Adjunct members	Martin Malmsten	University of Copenhagen
	Ola Wendt	Lund University
Electrical Engineering and Computer Sciences	Thore Husfeldt	Lund University
	Niklas Rorsman	Chalmers University of Technology
	Thomas Schön	Uppsala University

	Katinka Wolter	Freie Universität Berlin
	Karl-Erik Årzén	Lund University
Adjunct members	Karl Henrik Johansson	KTH Royal Institute of Technology
	Andrei Sabelfeld	Chalmers University of Technology
Geosciences	Daniel Conley	Lund University
	Emma Kritzberg	Lund University
	Vivi Vajda	The Swedish Museum of Natural History
	Pär Weihed	Luleå University of Technology
	Qiong Zhang	Stockholm University
Adjunct members	Raimund Muscheler	Lund University
	Anna Rutgersson	Uppsala University
Mathematics	Björn Birnir	University of California, Santa Barbara
	Tara Brendle	University of Glasgow
	Gunilla Kreiss	Uppsala University
	Ilya Pavlyukevich	University of Jena
Adjunct members	Tobias Ekholm	Uppsala University

	Holger Rootzén	Chalmers University of Technology
Mechanical, chemical and biomedical engineering	Shervin Bagheri	KTH Royal Institute of Technology
	Magnus Cinthio	Lund University
	Louise Olsson	Chalmers University of Technology
	Solveig Melin	Lund University
	Ulrika Rova	Lund University
	Mohammad Taherzadeh	University of Borås
	Karin Wårdell	Linköping University
Adjunct members	Francisco Javier Vilaplana Domingo	KTH Royal Institute of Technology
	Carolina Wählby	Uppsala University
Physical sciences	Eleanor Campbell	University of Edinburgh
	Vanya Darakchieva	Linköping University
	Katia Gallo	KTH Royal Institute of Technology
	Fariba Hatami	Humboldt-Universität Berlin
	Anders Johansen	Lund University
	Susanne Mirbt	Uppsala University

	Anders Nilsson	Stockholm University
	Christopher Plummer	École Polytechnique Fédérale de Lausanne
	Marika Taylor	University of Southampton
	Lars Österlund	Uppsala University
Adjunct members	Lars Berglund	KTH Royal Institute of Technology
	Mattias Marklund	University of Gothenburg
	Floriana Lombardi	Chalmers University of Technology
	Christian Brylinski	University of Lyon
	Ludvig Edman	Umeå University

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3 Review panels within natural and engineering sciences

3.1 From 2021 and onwards

Name	Focus areas
NT-A Atmospheric, Aquatic, and Soil Sciences	Biogeochemistry, Climatology, incl. climate modelling; Environmental chemistry; Hydrology; Limnology; Meteorology and atmospheric science; Oceanography; Soil science
NT-B Geology, Geochemistry, and Geophysics	Geochemistry; Geodesy; Geology; Geophysics; Geotechnical engineering; Glaciology; Mineralogy and petrology; Palaeoclimatology, incl. palaeoclimate modelling; Palaeoecology; Palaeoceanography, incl. palaeoceanographic modelling; Palaeogenetics; Palaeontology and palaeobiology; Physical geography; Sedimentology; Tectonics; Quaternary geology, incl. Paleolimnology
NT-C Evolutionary Biology and Genetics	Biological systematics; Comparative biology; Evolutionary biology; Evolutionary ecology; Evolutionary developmental biology; Evolutionary genomics; Phylogenetics; Population genetics
NT-D Ecology and Organism Biology	Behavioural ecology; Biodiversity; Community ecology; Ecophysiology, Ecosystems, Ethology; Marine biology; Microbial ecology; Plant and Zoophysiology; Plant-environment, -microbe-interactions; Toxicology
NT-E Cell Biology, Developmental Biology, and Microbiology	Cell biology; Developmental biology; Epigenetics; Functional genomics; Immunology; Microbiology; Neurobiology and neurochemistry
NT-F Biochemistry, Molecular Biology, and Structural Biology	Biochemistry; Molecular biophysics; Molecular biology; Molecular biotechnology; Structural biology

NT-G Analytical, Physical, and Theoretical Chemistry	Analytical chemistry; Non-targeted and targeted analysis; Physical chemistry; Molecular spectroscopy; Surface and colloid chemistry; Soft Matter; Biophysical chemistry; Theoretical chemistry; Molecular simulations; Quantum chemistry
NT-H Inorganic, Materials, and Organic Chemistry	Inorganic chemistry; Bioinorganic chemistry; Coordination chemistry; Electrochemistry; Solid-state chemistry; Materials chemistry; Green chemistry; Organic chemistry; Medicinal chemistry; Organometallic chemistry; Polymer chemistry
NT-I Materials Science and Engineering	Biomaterials; Ceramics; Composite materials and composite engineering; Corrosion engineering; Manufacturing, surface and joining technology; Materials design; Metallic materials and metallurgy; Polymers and polymer engineering; Thin film materials
NT-J Bioprocess Technology, Chemical Engineering, and Environmental Engineering	Biocatalysis and enzyme technology; Bioenergy; Bio-nanotechnology; Bioprocess technology; Catalysis; Chemical engineering; Environmental technology; Food chemistry; Food technology; Natural resources engineering; Paper, pulp and fibre technology; Pharmaceutical biotechnology; Water engineering
NT-K Applied and Engineering Physics	Semiconductor physics; Electronic devices; Surface physics; Low-temperature physics; Magnetism and spintronics; Superconductivity; Photonics; Optoelectronic technology and instrumentation; Sensor technology; Biophysics; Mesoscopic physics
NT-L Astronomy and Subatomic Physics	Accelerator physics; Astronomy; Astroparticle physics; Astrophysics; Cosmology; Mathematical physics; Nuclear physics; Particle physics; Radiation physics (non-medical aspects)
NT-M Physics of Light and Matter	Atomic physics; Molecular physics; Cluster physics; Condensed matter physics; Soft matter physics, Plasma physics; Space physics, Fusion; Chemical physics; Fundamental optics; Quantum information

	and quantum optics; Quantum liquids and quantum materials
NT-N Mechanical Engineering	Aerospace engineering; Biomechanics; Energy engineering; Fluid mechanics and acoustics; Mechanics of materials; Nuclear engineering; Rheology; Solid mechanics; Tribology; Vehicle engineering
NT-O Biomedical Engineering	Artificial organs; Biomaterials; Biomechanics; Bio-optics; Biosensor technology; Medical biotechnology; Medical equipment engineering; Medical ergonomics; Medical Image and Signal Processing; Medical informatics; Medical laboratory technology and measurement technology; Medical materials and prosthesis technology; Physiological Measurement Technology and Modelling; Radiation physics (medical aspects); Radiology and image processing; Speech Technology and Technical Audiology
NT-P Systems and Electrical Engineering	Analog and digital electronics; Communication and information theory; Computer vision; Control engineering; Electrical and power engineering; Machine learning; Networked systems; Radio engineering; Robotics; Signal processing
NT-Q Computer Science	Algorithms; Artificial intelligence; Computer systems (computer architecture, embedded systems, computer networks, and operating systems); Human-computer interaction; Information systems; Parallel and distributed computing; Programming languages and systems; Security; Software engineering; Theory of computation
NT-R Computational Mathematics, Data Science, and Statistics	Computational mathematics and numerical analysis; Foundations of data science; Natural language processing; Operations Research; Scientific computing; Statistics
NT-S Mathematics	Algebra; Analysis; Applied mathematics; Discrete mathematics; Geometry; Mathematical logic; Number theory; Probability theory; Topology

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Name	Focus areas
NT-1 Mathematical Sciences	Algebra; Computational mathematics and numerical analysis; Discrete mathematics; Geometry; Mathematical logic; Mathematical analysis; Optimization; Probability theory and statistics; Systems theory; Applied mathematics
NT-2 Computer science	Computer architecture; Systems engineering; Computer engineering; Interaction Technologies; Human-Computer interaction (Interaction Design); Software engineering; Language technology (Computational linguistics); Information systems; Theoretical computer science
NT-3 Subatomic physics, space physics and astronomy	Accelerator physics; Astrophysics; Astronomy; Astroparticle physics; Fusion; Cosmology; Mathematical physics; Nuclear physics; Plasma physics; Particle physics; Space physics; Radiation physics (non-medical aspects)
NT-4 Atomic and molecular physics, optics and condensed matter physics	Atomic and molecular physics; Computational physics; Chemical physics; Cluster physics; Condensed matter physics; Quantum information and quantum optics; Quantum liquids and quantum materials; Macromolecular physics; Optics; Statistical physics; Structural and vibrational physics
NT-5 Analytical, physical and theoretical chemistry	Analytical chemistry; Biophysical chemistry; Physical chemistry; Chemometrics; Quantum chemistry; Microfluidics; Molecular simulations; Theoretical chemistry; Surface and colloid chemistry
NT-6 Organic and inorganic chemistry	Bioinorganic chemistry; Electrochemistry; Pharmaceutical chemistry; Solid-state chemistry; Cluster chemistry; Nuclear chemistry; Solution chemistry; Materials chemistry (synthesis aspects); Organometallic chemistry; Inorganic chemistry; Organic chemistry; Polymer chemistry
NT-7 Geology and geophysics	Geodesy; Geophysics; Geology; Geotechnical engineering; Glaciology; Quaternary geology; Mineralogy; Physical geography; Palaeoclimatology;

	Palaeontology and palaeobiology; Petrology; Tectonics
NT-8 Soil, air and water processes	Geochemistry; Hydrology; Environmental chemistry; Climatology; Soil science; Meteorology and atmospheric science; Oceanography
NT-9 Biochemistry and structural biology	Biochemistry; Glycobiology; Nucleic acids biochemistry; Protein chemistry and enzymology; Molecular biophysics; Molecular biotechnology; Structural biology
NT-10 Cell and molecular biology	Cell biology; Epigenetics; Functional genomics; Immunology; Molecular biology; Neurobiology and neurochemistry; Proteomics
NT-11 Organism biology	Bioinformatics; Botanics; Genetics; Microbiology; Systems biology; Toxicology; Developmental biology; Zoology
NT-12 Ecology, systematics and evolution	Biological systematics; Ecology; Ethology; Evolutionary biology
NT-13 Electronics, electrical engineering, semiconductor physics and photonics	Electrical measurement technology and instrumentation; Electrophysics; Electronics; Electrical engineering; Power engineering; Photonics; Semiconductor physics; Radio engineering
NT-14 Signals and systems	Computer vision; Communication systems; Control engineering; Robotics; Signal processing
NT-15 Applied physics	Biophysics; Low-temperature physics; Magnetism and spintronics; Mesoscopic physics; Nanoscience and nanotechnology; Sensor technology; Superconductivity; Thin film technology; Surface and colloidal physics

NT-16 Mechanical engineering	Biomechanics; Energy engineering; Vehicle engineering; Solid mechanics; Mechanics of materials; Rheology; Reactor science; Aerospace engineering; Fluid mechanics and acoustics; Tribology
NT-17 Bioprocess technology, chemical engineering and environmental engineering	Bioenergy; Biocatalysis and Enzyme technology; Bio- nanotechnology; Bioprocess technology; Catalysis; Chemical engineering; Food chemistry; Food technology; Pharmaceutical biotechnology; Environmental technology; Natural resources engineering; Paper, pulp and fibre technology; Water engineering
NT-18 Materials science	Manufacturing, surface and joining technology; Ceramics; Composite materials and Composite engineering; Corrosion engineering; Materials design; Materials characterisation; Materials chemistry (not synthesis); Materials structure; Metallic materials and metallurgy; Polymers and polymer engineering; Thin film materials
NT-19 Biomedical engineering	Artificial organs; Biomaterials; Bio-optics; Biosensor technology; Physiological measurement technology and modelling; Medical equipment engineering; Medical image and signal processing; Medical biotechnology; Medical ergonomics; Medical informatics; Medical laboratory technology and measurement technology; Medical materials and prosthesis technology; Radiology and image processing; Radiation physics (medical aspects); Speech technology and technical audiology

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