



Evaluation 2017 - 2022

NWO Institute SRON
Netherlands Institute for Space Research

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1. Foreword by the committee chair

SRON Netherlands Institute for Space Research is the national space institute. It is of central importance for the scientific and technologic research in the Netherlands in space astronomy and in Earth observations, and essential for the very high international visibility of the Netherlands in this area. In this report, the Review Committee summarizes its main conclusions and recommendations for SRON in the next years. It is based on extensive input provided by SRON in its self-evaluation and from input during its on-site visit on 5-6 October 2023 at SRON's main site in Leiden.

The extensive self-evaluation provided the committee with a very good overview of SRON's previous activities and plans, illustrating the impressive scientific and technological achievements of the institute. The Committee thanks everybody who was involved in the preparation of the self-evaluation for their effort, which provided a good basis for the discussions during the site visit.

During the site visit, the Review Committee held round table discussions with employees and management of SRON at all stages of expertise, including technical and engineering staff, administrative staff, research staff and management, and from all research areas. The committee also had dedicated meetings with stakeholders focusing on the education of early stage researchers and on questions of equity, diversity, and inclusion, as well as with representatives from the Scientific Advisory Council, the Dutch and international space industry, the European Space Agency, and the government. This helped in obtaining a good view of the current status of SRON, as outlined later in this report.

Finally, the committee was also provided with an interesting tour of the impressive facilities that are available in the new building at SRON. Unfortunately, a tour of the facilities in Groningen was not possible due to time reasons, however, a video presentation prepared by SRON staff gave at least a glimpse into this location. The site visit concluded with a presentation of the committee's preliminary findings and conclusions.

The site visit was intensive, but also very rewarding for the committee. We thank everybody who was involved in the preparation of the visit for the smooth preparation. The committee encountered a world-leading scientific institution with a very impressive track record during the reporting period. We congratulate all members of SRON for their achievements. The committee thanks all participants during the visit for the open exchange of opinions and ideas, and especially also the willingness of all of our discussion partners to not shy away from talking about critical items during the site visit. These are especially important for formulating the recommendations in this report. We hope that these will help the management and all members of SRON to strengthen their institute even further.

Prof. dr. Jörn Wilms
committee chair

2. Executive summary

SRON Netherlands Institute for Space Research, as the national expertise centre for space research, SRON combines fundamental scientific research, technology innovation and instrument development to enable breakthroughs in space science. SRON is the national base for the Dutch participation in the ESA science programme. In partnership with space agencies (such as ESA, NASA, and JAXA) SRON provides technological contributions to international space missions. In collaboration with Dutch universities, other NWO institutes and Dutch government agencies, SRON pursues a cohesive national agenda for space-based research.

SRON's vision centers on advancing the Netherlands' position in international space research. It excels in astrophysics, Earth science, and technology development, evidenced by its role in projects like TROPOMI/Sentinel-5P and the X-IFU instrument on Athena. Earth Science aligns with climate research, including greenhouse gas observations. In astrophysics, SRON's focus on the X-IFU instrument and expertise in MKIDs for infrared astronomy are praised. However, concerns arise about the concentration on specific technologies without a clear long-term strategy, especially if no IR probe is selected. Recommendations include formalizing a long-term technology development plan, possibly through a "SRON roadmap," and reorganizing programmes for better collaboration. Specifically, the committee suggests merging astrophysics and exoplanet programme into a "universe programme," fostering cross-programme collaboration. Prioritization and transparency in technology development, aligning with strategic and financial cycles, are urged. The importance of a clear short- and long-term science and technology roadmap is emphasized.

Research Quality

SRON has excelled in Earth sciences and Astrophysics during the reporting period, making noteworthy contributions through numerous scientific publications and data exploitation by global scientists. The institution's success is evident in space-based research, and its reputation is highly regarded by major partners like ESA and NASA. In Astrophysics, SRON's space instruments, including the still operational XMM-Newton's RGS, and the recent XRISM launch, set new standards. The institution also contributes significantly to data science and software tools development. TROPOMI's deployment on Sentinel-5P is a standout achievement, enabling groundbreaking science, such as identifying methane super emitters. In technology, SRON leads in cryogenic photon detectors and has potential opportunities in quantum information science. The committee recommends increased collaboration with universities to explore quantum advancements for future instruments.

Societal Relevance

SRON, as the national space institute, plays a pivotal role in providing payloads for significant space missions, fostering excellence in space research, and acting as a crucial link between international space agencies, Dutch universities, and the private sector. Its societal impact is evident through a robust sensor development program with applications across diverse scientific domains. SRON contributes significantly to basic research in astronomy and astrophysics, and addresses critical issues such as greenhouse gas monitoring, notably discovering methane superemitters. The institute's involvement in Earth observation, though less formalized with universities, is acknowledged, prompting a recommendation for a closer cooperation with Dutch universities and institutes in Earth observation. SRON also makes valuable contributions to vocational training through the Leidse Instrumentmakers School. The institute actively engages the public through various communication channels, including a new mobile planetarium, yet seeks

to enhance visibility beyond the scientific community by exploring collaborations with science museums, planetaria and amateur astronomy communities.

Recommendations include implementing plans for closer cooperation with Dutch universities in Earth observation, similar to the Committee for Astronomy/NOVA model, and exploring personal links like professorship co-appointments. The committee applauds SRON's outreach efforts and suggests further connections with large-dome planetaria and amateur astronomy programs for increased public engagement.

Viability

SRON's ambitious goals focus on securing the Netherlands' strategic position in global scientific projects, such as ESA's Voyage2050 and NASA's decadal survey frameworks. Despite limited resources, SRON excels in gaining recognition in scientific fields and political support for initiatives like greenhouse gas monitoring. Participation in missions like Ariel and Athena and contributions to future flagship missions, such as the Habitable Worlds Observatory, are crucial for scientific advancement. Close collaboration with universities enhances SRON's impact on science and society, but bureaucratic limits hinder collaboration on new technologies. Recommendations include raising awareness of funding challenges for industry involvement in early technology development.

In Astrophysics, SRON focuses on contributions to Athena and IR missions, while in Earth sciences, it excels in atmospheric composition, addressing climate-related aspects and air quality monitoring. Well-connected internationally, especially with ESA, NASA, and JAXA, SRON leads three missions and contributes to 10% of all ESA Voyage 2050 proposals. Previous aims for collaboration with China have evolved, with the contribution to eXTP ending. Despite challenges from relocating to Leiden amid the pandemic, SRON's risk mitigation strategies, like a commuting allowance, proved effective. The move was successful, with no critical project revisions and overall staff satisfaction, commended by the committee.

The overall matrix structure of SRON appears to work well. The hierarchy seems to be flat enough for a vibrant functioning and academic freedom yet efficient in not overcharging scientists with bureaucracy. The only concern the committee had was regarding both the apparent lack of clear internal organization within the astrophysics programme and the somewhat artificial separation of exoplanets from the rest of the astrophysics programme.

Actively shaping the scientific landscape, SRON's work on X-ray interferometry is now part of ESA's roadmap. However, concerns include a lack of internal organization in astrophysics and the separation of exoplanets. In Earth sciences, project funding is robust at 40%, showcasing research excellence, but reliance on such funds poses a risk. Financial stability is a concern, especially with inflation and goals of staff increase. Personnel risks involve dependency on shared positions with universities, and the management's plan for mentoring and training is praised. Concerns arise about work pressure and potential single-point failures. Knowledge transfer issues emerge with retiring staff, prompting a recommendation for additional funding and strategic hires. Funding for technology development faces challenges in aligning with long-term goals, leading to a recommendation for strategic discussions with external partners to secure necessary funding. Overall, SRON's institutional goals align with NWO's vision and strategy, emphasizing the need for strategic financial planning and collaboration with funding agencies to ensure long-term viability.

Specific Aspects

SRON builds on the long standing open data tradition in space astronomy by demonstrating a strong commitment to open science with a 2020 open data policy, employing dedicated data stewards, and utilizing

zenodo for data and software publications. The approach succeeds despite potential challenges from private partners. NWO policies contribute to the clarity of this implementation.

SRON has a well-structured PhD program with clear guidelines, supervision, and schedules, emphasizing early career researchers' recognition through PhD publications. While the program duration is good, alignment issues with graduation criteria at partner universities are noted. The recommendation is to raise awareness at the university level that strict numerical requirements for the number of publications required for a PhD may not be the optimal metric of excellence/graduation requirements. Interdisciplinary theses pose challenges, requiring clear supervisor responsibilities. The committee suggests aligning processes with partner universities to avoid duplication, e.g., related to mandatory advisory committee meetings. PhD researchers appreciate the flat hierarchy but highlight the need for dedicated desk space at SRON for better integration and communication. The committee emphasizes the importance of designated spaces for cohesion and communication among PhD candidates.

SRON's inclusive approach involving students from Bachelor's to high school promotes talent recruitment. Senior staff teaching at various universities enhances this initiative. The committee supports talent recruitment policies, including offering permanent contracts for grant recipients. Postdocs can engage in teaching through personal networks. Early career scientists value support, academic freedom, and the mentor buddy program. Interactions with scientists are productive, and the career path is seen as fair. However, there is a call for increased transparency in decision-making about permanent positions and career advancement criteria. Work-life balance, especially for senior and part-time staff, is advised, with attention to potential burnout. Joint appointments may pose challenges, and improving talent management is encouraged. Stakeholder sessions indicate a healthy relationship between SRON and stakeholders.

The committee commends SRON's management for actively pursuing diversity initiatives, particularly in addressing the low representation of female staff. The implementation of hiring procedures to enhance objectivity is noted, and recent appointments have positively impacted the gender balance in the management team. While the long-term goal of achieving at least 30% women in staff is supported, achieving this target may be challenging and requires a thorough examination of recruitment and retention dynamics.

The committee recommends prioritizing cultural awareness and diversity training, involving external consultants for an unbiased approach. Despite positive efforts, some reports indicate lingering prejudice and disagreement among staff. The committee emphasizes the importance of scientifically motivated strategies for cultural change.

Regarding career development, SRON is praised for supporting staff across career levels and recognizing excellence beyond research output. The strategic plan for funding staff development and succession planning is welcomed, with a recommendation to strengthen relationships with stakeholders and consider a development course for staff covering various aspects of the astronomy landscape.

3. Procedure

3.1 Scope of the evaluation

This evaluation was carried out as part of the six-yearly evaluation of the nine research institutes of the Dutch Research Council (NWO). NWO asked evaluation committees of external peers to perform an evaluation of its research institutes over the period 2017-2022. Evaluation bureau Academion acted as independent intermediary to safeguard the quality of assessment, providing secretaries for each of the site visit and helping the institutes and evaluation committees prepare and execute the site visits together with NWO-I, the institute organization of NWO.

The evaluations were carried out according to the Strategy Evaluation Protocol 2021-2027 (SEP), the protocol for research evaluations in the Netherlands, agreed upon by NWO, the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Universities of the Netherlands (UNL). The committees were requested to carry out the evaluations according to a list of questions derived from the main assessment criteria of SEP (see appendix 1). The assessment was to include a backward-looking and a forward-looking component. The committees were asked to judge the performance of the institute based on the list of SEP questions and to offer its written conclusions as well as recommendations based on considerations and arguments. The main assessment criteria are:

- Research Quality;
- Societal Relevance;
- Viability.

During the evaluation of these criteria, the committees were asked to incorporate four specific aspects relating to how the institute organises and actually performs its research, its composition in terms of leadership and personnel, and how the institute is run on a daily basis. These aspects are:

- Open Science;
- PhD Policy and Training;
- Academic Culture;
- Human Resources Policy.

For more information on the SEP questions, see Appendix 1.

3.2 Composition of the committee

The committee for the evaluation of the SRON Netherlands Institute for Space Research was appointed by the Board of NWO, and consisted of the following members:

- Prof. dr. Jörn Wilms, Karl-Remeis Observatory, FAU Erlangen-Nürnberg, Germany (chair);
- Dr. Melissa McClure, Leiden University, Netherlands;
- Dr. Susanne Mecklenburg, ESA Climate Office, UK Earth observation, atmospheric science, UK;
- Dr. Omid Noroozian, NASA, USA;
- Prof. dr. Johannes Quaas, Leipzig University, Germany.

The committee was supported by Liza Kozłowska (Odion Onderzoek BV) who acted as secretary on behalf of Academion. Iris Koopmans was present during the site visit to support the committee on behalf of NWO-I.

3.3 Independence

Before the site visit all members of the committee signed the *NWO Code of Conduct*, by means of which they declared that their assessment would be free of bias and without regard to personal interest, and that they had no personal, professional or managerial involvement with the institute or its research programmes. It was concluded that the committee had no conflicts of interest. The NWO-I coordinator present during the site visit did not take part in the evaluation, but provided the committee with background information and context on the position of the NWO institute upon request.

3.4 Data provided to the committee

The committee received the following documents:

- Self-Evaluation Report SRON 2017-2022, including appendices (on SRON organization, financial overviews, research bibliometrics, case studies, facilities, education, economic impact and outreach);
- SEP 2021-2027;
- Terms of Reference;
- Information on gender and national/international staff balance in the NWO-institutes;
- Information regarding open science in SRON

The committee was positive on the quality of the information received. The self-evaluation report, appendices and case studies painted a clear picture of the mission, strategy and accomplishments of SRON.

3.5 Procedures followed by the committee

The committee proceeded according to the SEP 2021-2027. The secretary instructed the committee chair on his role in the evaluation. In its first meeting on 19 September 2023 the committee was briefed by the secretary on research evaluations according to the SEP 2021-2027, and by the NWO-I coordinator on the Dutch research landscape and position of the NWO institute therein.

Prior to the site visit, all committee members independently formulated a preliminary evaluation based on the written information that was provided before the site visit. During its preparatory meeting on 19 September 2023, the committee discussed the preliminary evaluations and identified questions to be raised during the site visit. It agreed upon procedural matters and aspects of the evaluation. The site visit took place on 5 October and 6 October 2023 (see the schedule in Appendix 2). After the interviews the committee discussed its findings and comments in order to allow the chair to present the preliminary findings and to provide the secretary with argumentation to draft a first version of the evaluation report. The final evaluation is based on both the documentation provided by SRON and the information gathered during the interviews with representatives of the institute during the site visit.

The draft report by the committee was presented to SRON for factual corrections and comments. In close consultation with the chair and other committee members, the comments received were reviewed to draft the final report. The final report was sent to NWO on 22 March 2024.

4. Evaluation of SRON 2017-2022

4.1 About SRON

SRON Netherlands Institute for Space Research is the Dutch national space research institute. It provides the Netherlands with the facilities and expertise to contribute instrumentation for international space missions, including the ESA science program, but also missions from other space agencies such as NASA or JAXA. It has a unique position in the Dutch scientific and technological space environment and is well connected nationally (through links to NOVA, ASTRON, universities etc) and internationally.

During 2017-2022, the institute has undergone significant (organizational) changes in globally challenging times of social, political and economic upheaval. The committee learned that the institute moved its headquarters from Utrecht to a new and modern facility in Leiden. A move of the Groningen facilities to a new building that also hosts the Kapteyn institute, is foreseen for 2027. The committee was impressed by the smooth handling of the recent move in the midst of a global pandemic, highlighting the high organisational resilience and scientific and technological excellence of SRON over the review period. The facilities contain all equipment to design and manufacture space-based instrumentation. In recent years, SRON delivered multiple instruments, including hardware for the recently launched XRISM mission – a precursor for ESA’s Athena mission -, the GUSTO balloon borne instrument, or the SPEXone instrument for NASA’s PACE Earth observation mission. It also provided significant contributions to larger astrophysics missions that are currently in preparation such as Athena and PLATO, and to ESA’s Sentinel Earth observing programme, in addition to contributing to a large number of smaller missions.

Besides the relocation of the institute, SRON welcomed new leadership in the directorate. Currently, SRON has a staff of about 190 FTE at a base funding of 15 Million EUR from NWO, 30% of which are instrument scientists, 55% are research scientists in various areas of space-based research. The institute also serves as a centre of excellence for the Dutch community with respect to the scientific exploitation of these missions. SRON collaborates closely with Dutch academic institutions and industry. It also represents the Netherlands in the relevant ESA committees, advises the Dutch government at the ESA council level, and on general issues in the area of space research.

4.2 Mission, vision and strategy

SRON’s vision is “to retain and expand the Netherlands’ position at the forefront of international space research both scientifically and technically”. In order to do so, SRON develops science cases, key enabling technologies, prototypes and demonstrators, space-qualified instrumentation and data analysis tools for a wide range of space missions. The committee commented positively on SRON’s clear mission and leading role in the Netherlands and beyond in astrophysics, Earth science using space data, and mostly the underlying technology development and engineering.

Regarding the strategy for 2023-2028, Earth Science emphasises climate research and the observations and improved understanding of GHG sources, which is of course a long-standing expertise for SRON tightly related to TROPOMI/Sentinel-5P, which has proven to be a major success. This is directly addressing the current climate science and policy concerns under the UNFCCC Paris Agreement. Mention is also made of aerosol forcing and its impact on climate as well as Tipping Points in particular in arctic areas and fires. The

committee questioned the new focus on Tipping Points though, wondering whether it was equally sound and well connected to SRON's expertise. In discussion it became clear that these activities are more related to synergistic exploitation of Earth observation data, with little staff resources involved, and should possibly more look at studies on the carbon, water and energy cycle, which is a new focus put forward by GCOS' updated implementation plan (2022). The committee provided some suggestions for links to in particular EU and ESA activities (e.g. link the ClearAir initiative to the Copernicus Atmospheric Monitoring Service CAMS and the associated health hub; raised awareness of upcoming ESA ITTs on GHG emissions focussing on methane hotspots, Tipping Points, Cross-ECVs; offered to link aerosol activities to WCRP's CMIP project office hosted by the ESA Climate Office).

In the area of astrophysics, the concentration on the X-IFU instrument on Athena continues the excellence in microcalorimetry from the Hitomi and XRISM missions. In infrared astronomy, SRON is a worldwide leader in the development of MKIDs, which are also baselined in proposals for astronomical infrared satellites to NASA's probe mission call. A contribution to such a mission, if selected, would leverage the large past investments into infrared sensors for the cancelled SPICA mission. The committee felt that the main technological focus was on the MKIDs, wondering about future developments and a long-term mission and strategy if no IR probe is selected in the NASA call. The committee expressed considerations with regards to adapting their technologies to shorter wavelengths, but similarly a long-term strategy for such activities seems to be missing, which would also cause the risk of losing expert knowledge due to the demographic structure within the relevant teams.

RECOMMENDATION: Identify technologies to be developed for missions in the next decades and formalise long-term planning for instrument technology development with science goals in Astronomy (including Exoplanets) as well as Earth observation ("SRON roadmap").

Even though the committee felt that SRON has a clear and scientifically motivated structure, the committee did not fully understand the separation of astrophysics and exoplanets, which might be a result of historical evolution. In addition, there is little coherence of the research directions of the individual members of the astrophysics programme. While they are mainly related to space missions SRON has contributed to, the breadth of the existing research leads to little collaboration and has the danger of becoming subcritical in individual fields. The committee felt that combining the programmes might foster further interactions and synergies among all scientists doing research in astronomy, and possibly envisage a larger role for exoplanet missions. The committee understood that further in-house expertise would be needed to enlarge activities and re-prioritisation of activities in a financial and schedule context, given a stable funding source.

RECOMMENDATION: (Re-)organization of the astrophysics and exoplanet programmes into focus groups in a "universe programme" should be a priority. Perform a review of what these foci should be, keeping in mind to get a critical mass of several senior scientists in each of these areas. Make a long-term plan for transition into this structure. Intensify cross-programme collaboration, leveraging joint interests, e.g., in data sciences.

The committee also enquired how - given the stable funding - prioritising is done amongst the different activities across SRON departments. This discussion was also related to the long-term strategy for technology development and reaching sufficient TRLs that are necessary to be able to propose technology to - for example - space agency calls for space missions (both astrophysics and Earth science) and instrumentation. A clear concept for this might help to ascertain that today's success of SRON continues into the future, with observational capabilities remaining at the forefront of SRON's expertise. On a more specific point, it is not completely transparent how the technology department distributes its person-power between

scientific target areas. The discussion also brought up the approach to aligning SRON technology development to the strategic and financial cycles of potential funders outside NWO support.

RECOMMENDATION: Define a clear priority order for goals and personnel hires, identifying what will be postponed to the next performance cycle if funding falls through, e.g., the universities cannot hire joint staff. Generate and communicate this priority list in a transparent way, with staff input. A short- and long-term science and technology roadmap can help with this.

4.3 Research Quality

SRON has made outstanding contributions in the reporting period to specific questions in Earth sciences and in Astrophysics. These contributions come from both, a high number of individual scientific publications under the leadership or with very strong contributions from SRON staff, as highlighted in SRON's report, as well as indirectly by the large number of scientists in the Netherlands and worldwide who exploit data taken with instruments built under the leadership or with strong contributions from SRON. The committee emphasizes that for an institution tasked with building space instrumentation, both channels are equally important measures of scientific quality. SRON is one of the leading institutions in space-based research in Europe and the world, and, given its comparably small size, punches well above its weight. This assessment is also confirmed by SRON's reputation review that was presented to the committee, where it received very high marks from large partners such as ESA and NASA.

On the astrophysics side, in addition to the already flying instruments (including XMM-Newton's RGS, which is still operational after more than twenty years in space), the recent launch of XRISM will provide Dutch and European scientists with access to the instrument with the highest spectral resolution in X-rays worldwide. It is expected that this instrument will revolutionize the analysis of astrophysical plasmas. SRON has also been instrumental in delivering new software tools to analyze these data, such as SPEX, and is preparing for the challenges posed by these instruments through building up a new research focus in the area of data science. As noted in the previous section, however, the breadth of SRON's astrophysics and exoplanet research effort might have also implies a danger that a critical mass in specific focus areas cannot be reached, although this need to focus the research will have to be balanced with the need of a breadth in science that is sufficient to continue driving SRON's instrumentation activities.

As SRON's self evaluation emphasises, the development, deployment and very successful exploitation of the TROPOMI instrument on Sentinel -5P was and continues to be an outstanding success. It enabled new science in multiple dimensions. As an example, the identification of methane super emitters is a unique capability and of far-reaching scientific but also societal value. Next and in addition to this, the successful development and delivery of the SPEXone instrument for the PACE mission is an outstanding achievement. The data from this polarimeter has the potential to deliver crucial new information specifically about aerosols and clouds and their role in the Earth's climate.

In the area of technology, SRON has had a major impact in cryogenic photon detectors for Astrophysics, from Far-IR to optical and X-ray, where it is a world leader. In addition to playing a leading role in the design of the primary instrument of Europe's next X-ray mission, Athena, SRON has continued its strong track record in the development of sensitive infrared and optical sensors. SRON early technology demonstrations of high sensitivity and energy resolving cryogenic photon detectors have been enabling for future Astrophysics space missions, such as the low-NEP MKIDs in the far-IR, photon-counting in the vis/IR and mid-IR. These have been baselined for the focal planes of the (potentially) next generation of infrared astronomy missions

in the recent NASA mission probe call and are also utilized in instrumentation for the Extremely Large Telescope. These applications illustrate well the scientific and especially technological leadership of SRON.

The committee notes that, given recent technological innovations in the area of quantum information science (QIS), quantum engineering, computing, and sensing, there is a potential opportunity at SRON to harness these new advancements to improve the performance of their future instruments (sensitivity, resolution, etc.). In particular, given that observational astrophysics is generally in the photon-starved regime, quantum enhancements could dramatically improve the next levels of detection sensitivity, and result in reduced instrument size and bend the cost curve of future large missions.

RECOMMENDATION: The committee recommends more collaborations with university departments such as the TU Delft, QuTech and others to generate awareness and stimulate innovation in the area of quantum sensing and engineering for infusion into space missions.

4.4 Societal Relevance

As the national space institute, SRON's societal relevance is defined by its task of being the main Dutch institute to provide payloads for major space missions, and its world-leading sensor development program that uses technology that is in principle applicable to a very wide range of scientific questions. It is a center of excellence in space research and instrumentation, serves as an important intermediary between European and international space agencies and Dutch Universities and the private sector, and is the main provider of advice on space-related issues to the Dutch government. The combination of instrument development and related scientific activities at SRON and the universities is crucial for maximizing the return to society. SRON's activities also provide the opportunity for training people in a large number of relevant technological and scientific fields, both through the PhD programme but also through advising a remarkable number of BSc and MSc students. This work is helped by the appointment of SRON scientists at Dutch universities, especially in astrophysics.

SRON's own interpretation of the mission is further corroborating this relevance, both through its large impact in basic research in astronomy and astrophysics as well as its widely-recognized specialization on politically and societally important topics such as the monitoring of greenhouse gases and their emissions, and on the role of aerosols in climate change. The discovery of methane superemitters from Earth by SRON researchers with SRON-developed instruments is remarkable and is playing a central role in UN activities to mitigate methane emissions as part of the Methane Alert Response System. The reputation review and discussions at the stakeholder meeting during the review show that stakeholders agree with this assessment.

Earth observations are far less well represented in formal university appointments than the astrophysics and exoplanet programmes, even when considering the smaller size of the programme. At the same time, however, the Earth programme contributes largely to supervising theses of university graduates at SRON. This shows that there is an interest in pursuing this field. The main reason for the lower involvement with universities appears mainly to be due to the far less strong integration of the earth observation/remote sensing community in the Netherlands, combined with the larger fraction of remote sensing research done outside of the university sector. The committee recommends that in its role as a national institute SRON spearheads an effort to investigate ways that will lead to stronger networking and coordination between the Dutch earth observation community. NOVA - which is characterized by a similar diversity in the use of instrumentation and scientific goals - can serve as a good example. Investment in formal teaching activities for students would also result in further integration with the relevant universities in the Netherlands and lead to a tighter overall integration of the remote sensing community in the Netherlands.

RECOMMENDATION: Implement the plans for closer cooperation with Dutch universities and institutes in Earth observation (towards a scheme as efficient as the Committee for Astronomy/NOVA). Also consider closer personal links to universities (e.g., professorship co-appointments with TU Delft) in Earth observation.

SRON also provides valuable expertise to vocational training through the *Leidse Instrumentmakers School* (LIS), both through lecturing/practical education and mutual use of facilities. The committee is impressed by these activities, which are a very important way to educate the next generation of people with practical knowledge in building specialised instruments who are crucial not only for SRON but also for all of the high-tech industrial base in the Netherlands. SRON stakeholders (Airbus, cosine) also report on the importance of the LIS alumni.

Space research is also one of the main drivers for students to seek a STEM-related education. The institute has a very successful programme of communicating space research to the general public through a broad portfolio of different activities. The uptake of SRON publications by national and international news media is impressive, including the increased activity and presence in social media and events, despite difficult conditions between 2020 and 2022. The outreach team works well with museums in the Netherlands. Despite these activities, the reputation survey conducted by SRON shows that visibility outside the scientific domain could be improved. The new mobile planetarium is a very good way of communicating astrophysics to the general community, especially schools, as evidenced by the very positive reactions similar activities received in the *Wissenschaftsjahr 2023: Das Universum* in Germany. The committee also commented that possible additional avenues to connect to the general public would be through cooperating with the community of large-dome planetaria in the Netherlands as well as through fostering close ties to the amateur astronomy community and its outreach programs.

4.5 Viability

Scientific and societal relevance of goals

SRON's future technology and science development goals are ambitious, focusing on securing the Netherlands strategic position in the most scientifically and socially relevant international projects, in particular ESA's Voyage2050 and NASA's decadal survey frameworks. These goals are consistent with SRON's demonstrated ability to punch higher than its weight class in terms of scientific and technological output, for the amount of FTE and funding resources to which it has access. Its goals and achievements in Earth sciences, astrophysics, exoplanets, and technology are widely recognized in the scientific field. They are also of large relevance for politics and society. An example is the support by the Dutch parliament for the greenhouse gas monitoring science and efforts. The partnership in the Clear air consortium, initially with KNMI, TNO and TU Delft, highlights the importance of the research focus in the Earth sciences on climate- and air quality-atmospheric composition.

On the astrophysics side, SRON's participation in missions, like Ariel and Athena, and its aspirations to contribute technology to the next generation of flagship missions, e.g., the Habitable Worlds Observatory (HWO), are critical to the scientific community. *Although NASA's flagship missions fall well outside of the next six year performance period, it is critical to ramp up the technology development supporting these missions right now, in order to cement the SRON's and the Netherlands' chances at participation in these missions when eventually they fly.* These goals would contribute to society by inspiring future scientists to pursue technical careers. To augment that contribution, the increasingly close collaboration with universities adds to the impact of SRON on both science and society, in particular, in its role for training students and early career scientists. SRON does an excellent job of fulfilling their national role, both by alignment with the Dutch universities' science goals through participation in the *Raad voor Astronomie* and (by jointly-appointed staff)

in the NOVA university network, as well as its close connection with industry partner stakeholders through its technology projects and educational training opportunities. Discussions with the stakeholders showed, however, that there are external bureaucratic limits, especially with respect to collaboration on new technologies.

RECOMMENDATION: Industry (especially SMEs) has an interest in already contributing to technology development at early TRL levels, but it appears that the funding schemes available such as KIC have requirements that are difficult to match, especially for SMEs mainly working on space-related technology. Generate awareness with the government agencies on this (in the institute's role as government advisor).

Aims, strategy, foresight of leadership

In Astrophysics, SRON has a well-defined goal with its contributions to Athena and various IR missions. In Earth sciences, SRON is on track to further develop its clear and excellent profile with a focus on atmospheric composition and here in particular on the aspects highly relevant in the changing climate (greenhouse gases, aerosols, clouds) but also for air quality monitoring. In both fields, SRON is excellently connected to other space agencies, notably ESA, but also NASA and JAXA. Taking the lead on three missions, and its involvement in 10% of all 94 ESA Voyage 2050 proposals, is a demonstration of both the institute's international success and leadership foresight in positioning themselves well for the future. In previous years there was also a strategic aim to increase collaboration with China in the Earth sciences and in astrophysics, however, the contribution to eXTP has been ended.

SRON's recent move to Leiden from Utrecht and the pandemic had the potential to challenge these goals. However, risk mitigation strategies undertaken by management, e.g., the commuting allowance to count commuting time as work time and allowing for some remote work, have been effective at stemming the potential losses. On the whole, the committee found that move has gone extremely well, particularly given the complicated impact of the pandemic. No critical revisions of projects were required, and the staff seem generally happy with the move and current work situation. The committee praises the institute for this.

Plans and resources

The overall matrix structure of SRON apparently works well. The hierarchy seems to be flat enough for a vibrant functioning and academic freedom yet efficient in not overcharging scientists with bureaucracy. SRON is also actively involved in shaping the long-term scientific landscape such as, e.g., the basic work on X-ray interferometry which is now a possible mission on ESA's roadmap (also because of contributions by SRON scientists).

The only concern the committee had was regarding both the apparent lack of clear internal organization within the astrophysics programme and the somewhat artificial separation of exoplanets from the rest of the astrophysics programme (see above). At the moment, the 2.5 FTE of exoplanet staff seem subcritical relative to the effort needed in the coming years for SRON's longer term HWO and Life mission goals. Similar questions apply to LISA. SRON contributing to it together with Nikhef is a very positive development, but somewhat disconnected with the research that is done at SRON, and there seems to be little/no opportunity to build a research group that has a critical mass.

In the Earth sciences, the project funding share for SRON is healthy at about 40%. The continuous success in obtaining project funding is a strong indicator of research excellence. In particular the individual successes (including four ERC projects as well as three NWO vidi grants) is excellent, although relying on such funding would obviously be a risk going forward. However, the overall base funding from NWO was approximately steady over the reporting period. Given the high inflation rates in recent years, this could be a risk, as steady

increases by 2-5% are required for a stable funding of staff, energy, and other costs. Given the goal of increasing the staff in the exoplanet and astrophysics programmes, this is concerning.

Regarding the internal financial planning for the next decade, budgets seem to be distributed annually, roughly within a corridor from previous years. However, the issue of funding is critical to ensuring that SRON can fully realize its goals, which, as stated above, are necessary to secure the Netherlands' place in the premier international missions of the next few decades.

Regarding personnel, a clear risk is that a number of the future hires depend on shared positions between SRON and universities, or even on university hires that are not formally linked to SRON in any way. Due to the present financial situation, the university stakeholders were very clear that there was very little chance of additional hires happening with the next performance cycle.

The management team has an excellent plan to develop the next generation through mentoring and training schemes. At the moment, junior staff in particular feel that their degree of mentorship is highly dependent on which group they are in, and they welcome a broader and more consistent program. Improvements to project management and resource management are also being put in place as focus for the strategy from 2023 onward, improving collaboration between groups internally and with stakeholders. The astrophysics programme is working on a FIR roadmap, for how to move forward after ESA's cancellation of the SPICA mission.

Staff say that they find SRON to be a great place to work, in general. One area that the management team could address better is employee concerns about the amount of future work pressure during the next 6 years and its impact on work-life balance. Notably, this comment was largely from younger male staff members. This was in some cases related to weekend and after-hours emails, which is an easily mitigated issue, and in other cases the need for additional personnel to handle the amount of work as operations ramp up for future missions. Separately, there was a strong concern from a few junior staff that if something were to happen to them that required them to take a few weeks or months off of work, that this would completely disrupt the workflow of their groups, i.e., that they themselves were potentially single point failures.

Along that line, several of the key members of the instrument science group (and engineering groups) are approaching retirement age. The management team is aware of this, in many cases, replacements have been recently hired. These senior/junior pairs are in the process of transferring knowledge. It requires careful coordination between the senior-junior pairs to ensure sufficient in person contact moments to achieve the necessary knowledge transfer. However, the committee heard that in a non-negligible number of cases the knowledge transfer is not succeeding as intended, either because there is insufficient overlap between outgoing and incoming staff, when new hires are delayed until the last minute for financial reasons, or when outgoing staff do not want to prioritize such knowledge transfer over their other daily tasks. This has led to knowledge being lost in a few cases.

RECOMMENDATION: SRON's current and future strength is threatened by the potential for single-point failures driven by staff specialization and heritage staff retirement in the next few years. The institute should look for additional funding streams in the short term to hire more permanent staff "replacements" and "backups" that overlap heritage staff with sufficient advance notice to facilitate proper knowledge transfer and prevent single point failures. Consider making successful knowledge transfer (up or down seniority level) part of staff performance evaluation criteria.

Regarding the funding of technology development, the ability of SRON to realize their ambitious goals depends critically on obtaining funding in the middle stages of technology maturation (i.e. TRL 2/3 up to TRL 5, the “valley of death” for technology maturation). Presently, there is a severe disconnect between the current available NWO funding schemes, which are geared towards universities’ shorter time frames of 3-5 years for PhD/PD hires, and the 10-20 year timeframes to mature new technology in support of ESA and NASA’s flagship international missions. Given that external funding comes from NWO, EU, NASA and ESA mainly, focussed discussions with these partners and possibly designing a strategy to these organisations schedules and priorities might be useful to maintain the level of external funding, allowing SRON to leverage its technology innovations in a way that secures Dutch participation in missions between 2030 and 2040.

RECOMMENDATION: SRON’s long term institutional goals and viability are threatened by the incompatibility of short-term funding cycles with the long-term technology and mission work in space science and technology (TRL “valley of death”). The institute should continue working with funding agencies, such as NWO and NSO, to generate awareness in order to secure longer-term funding for such critical technology developments.

Viability in relation to developments in research field, society and institutional context (including national role and contribution to the NWO vision on ‘Dutch research in 2030’ as stated in its strategy)

SRON’s goals are well in line with NWO’s vision strategy. In the Earth sciences section, the institute has identified the greenhouse gas emission monitoring as a crucial development in climate change policies. Its unique contributions to this are essential for verifying the emissions reporting. The successful development of the SPEXone instrument is a major step forward to understand the role of aerosols for climate.

4.6 Specific aspects

Open Science

Space-based astronomy has a long tradition of open data access after brief (1 year) proprietary periods. It is not surprising, therefore, that SRON very credibly is dedicated to open science. In 2020 it implemented an open data policy. All major principles related to higher level data products are addressed, i.e., access to publications, reproduction data packages accompanying the publications, dedicated data stewards, following FAIR principles, training to adopt data principles, etc.. It is very positive for the entire field that a satellite organisation is leading this progress.

The fact that there are dedicated staff - five data stewards aiding scientific staff at documentation and publication - is a very useful element that has excellent potential to make this approach tractable for the individual scientists. In personal interaction, the dedication of the data stewards towards the open science goals became evident. SRON makes use of zenodo for data and software publications, which is a viable and functional choice. Software (e.g., retrieval algorithms, analysis software such as SPEX, etc.) are increasingly published as well, via zenodo and SRON’s own webpages.

The committee emphasizes that SRON’s commitment to open science is successfully being implemented despite the sometimes more proprietary attitude of private partners. The clarity of NWO policies is instrumental in making this happen.

PhD Policy and Training

A detailed PhD programme is in place including clear supervision guidelines and schedules (initial period, extension, section 8.3). The fact that the report cites PhD publications and results as research highlights emphasises the recognition the early career researchers get at SRON. The formal structures for PhD advice, together with partner universities, are very good. This includes the quality assurance by intermediate

meetings. The duration documented for the reporting period is good, a good fraction finish successfully before ending their 4-year contracts, and most theses are successfully completed before 5 years (see appendix 3). The committee welcomes that the SRON management aims to grant extensions for PhD candidates in cases where there are good reasons (also for university-employed candidates).

A problem is, however, that the criteria for PhD graduation at the various universities are not aligned, and that some universities also appear to mis-interpret recommendations, e.g., for the number of (first author) refereed publications as cast in stone. These recommendations also often do not take into account possible other boundary conditions that may arise in international project work, and SRON is recommended to have an open exchange with the universities to raise awareness about these issues.

RECOMMENDATION: Ensure awareness at the university level that strict numerical requirements for the number of publications required for a PhD may not be the optimal metric of excellence /graduation requirements.

Interdisciplinary theses with multiple advisers are a challenge, and responsibilities of each supervisor need to be clear. Where the main responsibility for a PhD thesis is outside SRON, it is useful if the SRON adviser would monitor the smooth functioning of the PhD advice (e.g., R&O talks). The PhD candidates report that the course programme works well. The committee welcomes that programme leads discuss career perspectives with PhD candidates early before their PhD project ends. It could be advisable that the programme leads participate in the R&O talks. In some discussions with PhD candidates, it appeared that SRON's approach and the committee meetings at the universities are done in parallel and/or use different forms. This leads to double work and an unnecessary bureaucratic burden that distracts from the primary aim of the talks. The committee suggests that SRON applies maximum flexibility with its own internal procedures and that it works with its partner universities to ensure that the processes align (e.g., by having SRON representatives attend the university status talks if applicable, rather than having multiple very similar meetings).

The PhD researchers report that they appreciate the flat hierarchy, and quote as a very positive example that the SRON director joins coffee conversations with PhD candidates, on the other hand, the lack of fixed desk space for PhD candidates at SRON (as opposed to the universities), hinders the integration of PhD candidates at SRON. Even if rooms are scarce, the committee thinks designated space for all PhD candidates are a prerequisite for dedication and inclusion of all PhD candidates performing research at SRON. This is true not only for cohort building, but also for improving the communication between PhD candidates in a given research area, but also for the communication within and across programmes.

Academic Culture

The large fraction of permanent staff (75%) is proof of the importance of sustainable conditions for its staff. It is a very good approach to offer permanent contracts beyond the base funding by assuming a steady influx of project funding. At the same time the system seems to leave enough flexibility for training of early career researchers.

The integration of international staff (specifically PhD candidates and junior staff) is reported to work well in principle in many programmes. This includes the ubiquitous use of English in conversations. The committee, however, also refers to the section on Diversity below for some critical issues and points for major improvement in this area.

Human Resources Policy

The committee welcomes the approach to involve students from as early as Bachelor's and Master's theses into SRON science, as this is a very good basis to select and attract qualified PhD candidates. An important basis for this is that multiple senior SRON staff teaches at several Dutch and foreign Universities. Even earlier, high school pupils are joining SRON for internships, as an important basis to attract young people to the topic early on. For the training of technical staff, the contribution to the *Leidse Instrumentmakers School* is appreciated.

The committee supports the talent recruitment policy (e.g., offering permanent contracts for Veni or Vidi grantees). Postdocs have the opportunity to be involved in teaching and student advice, necessary University involvement is via personal networks. Early career scientists feel supported and appreciate academic freedom. The mentor buddy programme is reported to be helpful. The interaction with other scientists is considered very good, open and productive. The career path at SRON is perceived as fair by early career scientists. While the path towards permanent employment via grant acquisition and other means is in principle transparent, staff expressed some unclarities with respect to the detailed criteria that need to be fulfilled as their careers progress. The committee suggests that such policies be even more clearly defined in documents that are accessible to all.

RECOMMENDATION: Improve transparency in decision-making and communication, particularly in terms of decisions about permanent positions and criteria for career advancement.

The management should also keep an eye on the work - non-work balance, in particular for senior staff and for part-time staff (e.g., by making this part of the R&O talks). There are however no hard constraints (e.g. meetings are only during core work hours). These statements are especially urgent for scientists in project roles, where the total amount of qualified staff is small and there is a danger of burn out. The committee understood that the management team is working on changing this. The committee also points out that the large number of joint appointments could be another challenge for all involved parties as there may be a preferential site where the scientist works, and/or there could be a work overload for the scientist.

Further appreciation of Talent Management is discussed below in Section "Talent Management and Career Perspectives". The committee concludes from the session with the stakeholders that there is in general a healthy, productive and mutually beneficial relationship between SRON and its stakeholders.

Diversity

The management team at SRON has implemented a comprehensive plan that aims at increasing the overall diversity of personnel employed at the institute. As already remarked on in the previous SEP report, the fraction of female staff at SRON is low, even compared to many of the other NWO institutes in the physical sciences. The ambition of the management team to further improve the diversity of its staff is very credible, and over the past years, SRON has strived to increase the share of female scientists. The new hiring procedures implement a practice that has the potential to improve the objectiveness of the hiring process and, with it, the success to attract a more diverse workforce. It is important that this is implemented throughout the departments. In fact, between the report and the on-site visit, three female leaders started their positions and presented SRON science, engineering and outreach aspects to the committee. With these new hires there are 50% women in the management team. This was reported in discussions with staff to have changed the culture to the positive.

The long-term goal to have at least 30% women in its staff across career stages is fully supported by the committee. Whether the strategic plan to achieve this in the coming reporting period is feasible and sustainable, however, is an open question. It would need a share of at least 50% female hires in the

upcoming replacements. Given the structure of the applicant pool, this may be challenging. In fact, the question of work hours was something that the young staff brought up, in relation to concerns about work-life balance and their families. However, it is currently unclear whether the gender imbalance is a problem with recruitment of female Dutch staff or with retention, both of which point to a different problem and corresponding solution. To first order, improving the accuracy of HR statistics would already help with defining the problem and mitigation strategy.

Until there is a clearer idea of whether the problem is recruitment or retention, and the differences between the impact on the Dutch versus international female staff, it might be advisable to shift the approach away from trying to reach a certain numerical goal at all cost, towards a sustainable increase in the overall diversity of the workforce at SRON. The committee acknowledges that it is not competent in advising on the best strategy on how to approach this problem and urges SRON to work with external consultants on diversity in human resources to study the best ways on how to proceed, since these also exceed the narrow field of space sciences.

Other dimensions of diversity in the culture at SRON are also acknowledged. The committee highlights the very good use of the “women in science excel” programme by both the Astrophysics and Earth observations programmes. Other action items include working groups targeting diversity and inclusion, more inclusive text in vacancy notices, women on interview panels, coming out days, training for unconscious bias for all staff, an internship programme for young females etc. These activities in the area of inclusion are commendable, including also the training activities to promote awareness. It is therefore credible that SRON’s management team pays attention to this and strives for a diverse workforce.

Despite these very positive efforts by the management team, reports to the committee during the site visit also reveal that at least in some parts of SRON there appear to remain prejudices against female staff members and a lack of cultural awareness that is at a level that is uncomfortably high. There also appear to be open disagreements by some of the staff with respect to the preferred hiring of women and minorities that seem to exceed the usual misgivings when such policies are introduced. It is critical for SRON to remedy this. Again, the committee recommends the use of outside consultants, with true independence from the internal SRON hierarchies, in order to understand the size of this problem and to solve it. Note that some approaches (e.g., blue-brown eye trainings) have even been demonstrated to produce more bias against minority groups in the long term. The committee therefore stresses that it may be advisable to check that the consultants use a scientifically motivated approach to culture change that takes into account findings from behavioural sciences about how to change people’s minds on a topic.

RECOMMENDATION: Make cultural awareness and diversity training a priority - fixing the overall workplace culture has to be part of this. Conduct an assay of where bottlenecks exist in current efforts, e.g., hiring vs. retention. Try to understand why certain teams are more successful in recruiting international women and others in recruiting Dutch women, and consider the disparate needs of those two demographics. Create unbiased hiring practices, consider the efficacy of the specific equality, diversity, and inclusion efforts and try to mitigate backlash against existing female employees (danger of quota backfiring on existing women).

Talent management and career perspectives

On the basis of the report and from the committee’s discussions with employees during the site visit, it appears that SRON very well supports the career development of its staff across career levels and both, among scientific staff and staff that supports science. The successes of SRON researchers in the ERC and competitive national programs speak to the quality and ambition of SRON scientists. Their successes in obtaining co-affiliations at Dutch universities also underline the scientific excellence and recognition of the

senior scientists and demonstrates the further development of their academic ambition as well as SRON's support for this.

SRON's strategy clearly aims to convey the recognition for excellence of staff beyond publications output, and balances this well in maintaining a focus on this research excellence as well. The annual results and development discussions with line managers are a good and certainly productive habit. It remains to be determined whether the evaluation process at programme and group level is efficient, but it has the potential to improve the feeling of participation and contribution to the overall SRON strategy and success.

SRON previously had a lack of formal career path mentoring. The strategic plan for dedicated funding for staff development and in particular succession planning has excellent potential and may prove very impactful if properly implemented. The committee especially welcomes the strategy to qualify skilled early career scientists towards an ability to become mission PIs, e.g., via mentoring by experienced mission PIs.

RECOMMENDATION: The committee observed a number of single point failures, in particular for the political aspects between SRON and industry or government stakeholders, when action depends on individual personal relationships. Finding a way to structurally ground or strengthen these relationships with new SRON staff, perhaps through rotating SRON representatives to a revitalized SPC contact committee, more frequent contact moments between SRON staff and government representatives, would help to ensure that SRON maintains its highly regarded institutional position and network within the Dutch policy landscape.

The younger staff were also enthusiastic about the idea of a development course. The committee notes that ESO has had something similar for its postdocs and PhD students for at least a decade, which has been well received. An opt-out development course that covered the Dutch (and European) astronomy landscape, grant applications, best research practices, and how to work cooperatively in an culturally blended environment could help to level the playing field for those staff who may not have as extensive local networks. It would also provide an opportunity to introduce some of the expected social behaviors in a way that does not frame them as “diversity questions”, but rather as advice on how to optimize their work at SRON and as SRON's representatives to international partners.

5. Conclusion and recommendations

Conclusion

SRON has a clear mission and role in Dutch and international research as the Netherlands' technological and scientific centre for space science. SRON is defined by its clear fields in which it is at the international scientific forefront.

List of recommendations

RESEARCH

1. (Re-)organization of the astrophysics and exoplanet programmes into focus groups in a “universe programme” should be a priority. Perform a review of what these foci should be, keeping in mind to get a critical mass of several senior scientists in each of these areas. Make a long term plan for transition into this structure. Intensify cross-programme collaboration, leveraging joint interests e.g. in data sciences.

2. Define a clear priority order for goals and personnel hires, identifying what will be postponed to the next performance cycle if funding falls through, e.g., the universities cannot hire joint staff. Generate and communicate this priority list in a transparent way, with staff input. A short and long term science and technology roadmap can help with this (see also next recommendation).
3. Identify technologies to be developed for missions in the next decades, and formalise long-term planning for instrument technology development with science goals in Astronomy (including Exoplanets) as well as Earth observation ("SRON roadmap").
4. Implement the plans for closer cooperation with Dutch universities and institutes in Earth observation (towards a scheme as efficient as the Committee for Astronomy/NOVA). Also consider closer personal links to universities (e.g., professorship co-appointments with TU Delft) in Earth observation.
5. The committee recommends more collaborations with university departments such as the TUDelft QuTec and others to generate awareness and stimulate innovation in the area of quantum sensing and engineering for infusion into space missions.

FINANCIAL AND PLANNING RISKS

6. SRON's long term institutional goals and viability are threatened by the incompatibility of short-term funding cycles with the long-term technology and mission work in space science and technology (TRL "valley of death"). They should continue working with funding agencies, such as NWO and NSO, to generate awareness in order to secure longer-term funding for such critical technology developments.
7. SRON's current and future strength is threatened by the potential for single-point failures driven by staff specialization and heritage staff retirement in the next few years. The institute should look for additional funding streams in the short term to hire more permanent staff "replacements" and "backups" that overlap heritage staff with sufficient advance notice to facilitate proper knowledge transfer and prevent single point failures. Consider making successful knowledge transfer (up or down seniority level) part of staff performance evaluation criteria.
8. Industry (especially SMEs) has an interest in already contributing to technology development at early TRL levels, but it appears that the funding schemes available such as KIC have requirements that are difficult to match, especially for SMEs mainly working on space. Generate awareness with the government agencies on this (in your role as government advisor).

SRON AS A WORK PLACE

9. Make cultural awareness and diversity training a priority - fixing the overall workplace culture has to be part of this. Conduct an assay of where bottlenecks exist in current efforts, e.g., hiring vs. retention. Try to understand why certain teams are more successful in recruiting international women and others in recruiting Dutch women, and consider the disparate needs of those two demographics. Create unbiased hiring practices, consider the efficacy of the specific EDI efforts and try to mitigate backlash against existing female employees (danger of quotas backfiring on existing women).

10. Improve transparency in decision making and communication, particularly in terms of decisions about permanent positions and criteria for career advancement.

EDUCATION AND OUTREACH

11. Consider implementing and expanding educational and outreach activities to a joint program between SRON and university staff to advertise SRON at the primary and secondary educational levels, in order to act as a feeder program for both the existing tertiary educational efforts and the new proposed female PhD/PD fellowship program.
12. Ensure awareness at the university level that strict numerical requirements for the number of publications required for a PhD may not be the optimal metric of excellence /graduation requirements.

SRON AND THE DUTCH SPACE SCIENCE COMMUNITY

13. There are also too many single point failures, in particular for the political aspects between SRON and industry or government stakeholders, when action depends on individual personal relationships. Finding a way to structurally ground or strengthen these relationships with new SRON staff, perhaps through rotating SRON representatives to a revitalized SPC contact committee, more frequent contact moments between SRON staff and government representatives, would help to ensure that SRON maintains its highly regarded institutional position and network within the Dutch policy landscape.

Appendix 1: SEP Questions Evaluation NWO institutes

The 3 main criteria:

1. Research quality:

- How does the assessment committee assess the scientific quality of the institute, in light of its own aims and strategy? Central in this assessment are the contributions to the body of scientific knowledge. The assessment committee is asked to reflect on the quality and scientific relevance of the research. Finally, the academic reputation and leadership within the field is assessed. Looking ahead into the future, which recommendations can the committee give to the institute regarding their research quality?
- How does the committee assess the institute's place in the national and/or international research landscape? Is the institute a frontrunner or a follower in its field? Does the committee see untapped opportunities?

2. Societal relevance:

- How does the committee assess the societal relevance in terms of impact, public engagement and uptake of the institute's research in economic, social, cultural, educational or any other terms that may be relevant? The assessment committee is asked to reflect on societal relevance by assessing an institute's accomplishments in light of its own aims and strategy. Looking ahead into the future, which recommendations does the committee have for the institute regarding its societal relevance?

3. Viability:

- How does the committee assess the extent to which the goals for the coming six-year period remain scientifically and societally relevant? It is also asked to assess whether its aims and strategy as well as the foresight of its leadership and its overall management are optimal to attain these goals. Finally, the assessment committee is asked to assess whether the plans and resources are adequate to implement their strategic plan. The assessment committee is also asked to reflect on the viability of the institute in relation to the expected developments in the field and societal developments as well as on the wider institutional context of the institute.
- How does the committee assess the way the institute fulfills their national role and does the committee have any recommendations regarding this?¹
- How does the committee assess the way the institute contributes to the vision on 'Dutch research in 2030' as is written down in the NWO Strategy 2023-2027 and does the committee have any recommendations?

¹ With respect to the reports from the PCNI, the portfolio committee and (where relevant) the exploration reports.

In addition there are also 4 important aspects contributing to the success of the institute:

4.1 Open Science

The assessment committee is asked to consider to which extent the institute opens up its work to other researchers and societal stakeholders in the context of its strategy and policy. Furthermore, the committee is asked to consider whether the institute reuses data where possible; how it stores the research data according to the FAIR principles; how it makes its research data, methods and materials available; and when

publications are available through open access. The committee is specifically asked to give the institute and NWO-I recommendations on their Open Access and FAIR data and software policy. The assessment committee is asked to reflect on the current policies, and the practices with regards to the open availability of the publications, research data and methods and assess them in light of NWO's high ambitions (e.g. is the institute a frontrunner in its field with regard to Open Access and FAIR data and software?).

4.2 PhD policy and Training

- The assessment committee is asked to consider the supervision and instruction of PhD candidates. Furthermore, the committee is asked to consider whether the quality assurance system is functioning properly. The committee is asked for recommendations on how to enhance the supervision and education of PhDs (together with the universities), also in light of the three main criteria.

4.3 Academic Culture

- *Openness, (social) safety and diversity & inclusivity:* The assessment committee is asked to consider the openness, (social) safety and diversity & inclusivity of the research environment. The assessment committee is also asked to evaluate the actions and plans for the future of the institute with regards to (social) safety, diversity & inclusivity.
- *Research integrity:* The assessment committee is asked to consider the institutes policy on research integrity as well as the way the institute facilitates the relevant actions and requirements formulated in the Netherlands Code of Conduct for Research Integrity. For both themes: Looking ahead into the future, which recommendations does the committee have for the institute regarding their academic culture, also in light of the three main criteria?

4.4 Human Resources policy

- *Talent Management:* The assessment committee is asked to consider the institute's policies on talent selection and development in relation to its aims and strategy. More specifically, it is asked to evaluate the institute's recruitment policies, opportunities for training and development, coaching and mentoring, as well as career perspectives for researchers and research support staff in different phases of their career. An important aspect of this is the (inter)national cultural change regarding recognition and rewarding in academia that NWO-I is implementing. What are the institute's plans to further the desired cultural change and which recommendations does the committee have for the institute and NWO-I?

Appendix 2: Programme of the site visit

Wednesday 4 October 2023

<17:00	Arrival of committee members in the Netherlands (Leiden)
17:30 – 18:00	Closed committee meeting with the chair of NWO Executive Board
18:00 – 21:00	Dinner (committee only)

Thursday 5 October 2023

08:30 – 09:00	Welcome at the SRON Institute
09:00 – 10:00	Interview with Institute Leadership
10:00 – 10:15	Committee closed session
10:15 – 11:25	SRON Research Programme I (Research Quality + Viability)
11:25 – 11:40	Break
11:40 – 12:30	SRON Research Programme II (Research Quality + Viability)
12:30 – 13:15	Lunch (with SRON Staff*) (*Unless Committee prefers closed session)
13:15 – 14:00	Committee closed session
14:00 – 14:15	Break
14:15 – 15:45	SRON Societal Impact
15:45 – 16:00	Committee closed session
16:00 – 17:00	SRON community stakeholder session
17:00 – 18:00	Tour of SRON
18:00 – 18:30	Walk to hotel
18:30 – 19:30	Committee closed session (Wrap up Day 1)
19:30 – 21:00	Dinner with committee and SRON staff
21:00	Close Day 1

Friday 6 October 2023

09:00 – 09:30	Arrive at the Institute
09:30 – 10:30	Sessions with PhD students
10:30 – 10:45	Committee closed session
10:45 – 11:30	SRON Academic culture and Talent Management
11:30 – 11:45	Break
11:45 – 12:30	Sessions with Junior Staff
13:00 – 14:00	Lunch with SRON staff
14:00 – 14:15	Formal conclusion to site visit (address SRON staff)
14:15 – 16:00	Committee closed session (drafting conclusions)
16:00 – 16:15	Break
16:15 – 17:00	Preliminary feedback to Institute Management
17:00 – 17:30	Transport to airport and train station
17:30	Closure of Day 2

Appendix 3: Quantitative data

Quantitative data on the institute's composition and funding:

Staff demographics

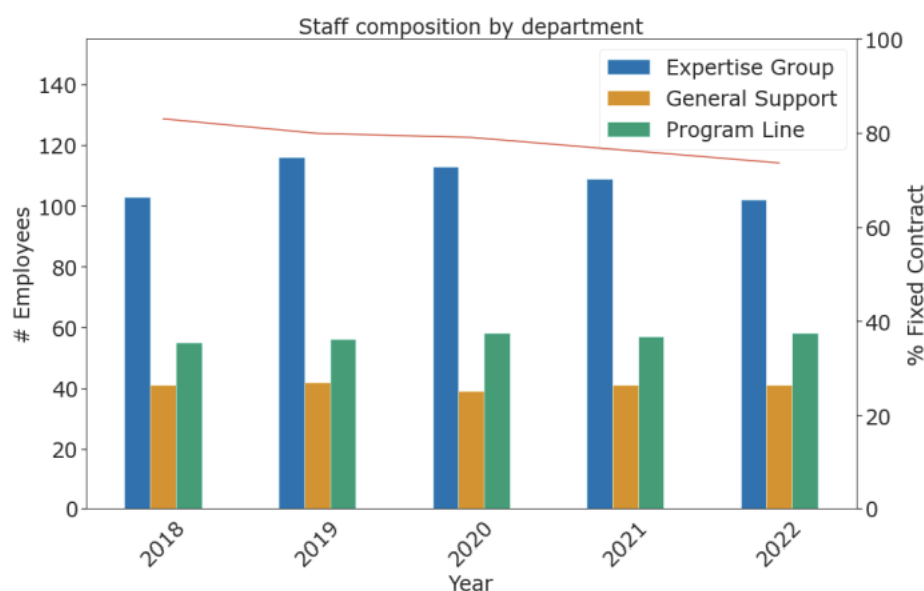


Figure: composition of SRON staff 2018-2022

Funding

P&L	2017	2018	2019	2020*	2021*	2022
Funding: k€						
Base funding *	14.900	15.265	16.903	20.148	21.228	21.334
Contracts/grants	4.673	7.735	9.132	7.244	5.905	6.130
Other	136	205	106	360	86	75
Total funding	19.709	23.205	26.141	27.752	27.219	27.539
Expenditure:						
Personnel costs	14.185	15.473	17.898	17.443	18.158	18.612
Other costs	4.999	6.956	7.488	6.236	11.126	9.305
Total expenditure	19.184	22.429	25.386	23.679	29.284	27.917
Operational result	...	...	...		...	...
Net result	525	776	755	4.073	-2.065	-378

Table: summary of SRON income and net results in the period 2017-2022.

*This value is total income. Due to the additional funding for the new housing, this figure is much higher than what can be allocated to the programme.

PhD

Enrolment			Success rates						
Starting year	Enrolment (male / female)		Total (M+F)	Graduated after < 4 years	Graduated after < 5 years	Graduated after < 6 years	Graduated after < 7 years	Not yet finished	Discontinued
2011	1	-	1	-	-	-	-	-	1/100 %
2012	1	-	1	-	1 / 100 %	-	-	-	-
2013	1	3	4	2 / 50%	2 / 50 %	-	-	-	-
2014	2	4	6	3 / 50%	2 / 33%	-	-	-	1/17%
2015	3	1	4	1 / 25%	2 / 50%	-	-	-	1/25 %
2016	7	1	8	-	5 / 63%	2 / 25%	-	-	1/12%
2017	1	1	2	2 / 100%	-	-	-	-	-
2018	3	2	5	2 / 40%	-	-	-	3/60%	-
2019	3	3	6	1 / 17%	-	-	-	5/83%	-
2020	2	-	2	-	-	-	-	2/100%	-
2021	6	2	8	-	-	-	-	7/88%	1/12%
2022	3	1	4	-	-	-	-	4/100%	-
Total	33	18	51	11 / 22%	12 / 24%	2 / 4%	-	21/ 41%	5 / 10%

Table: Overview of PhD students supervised during the reporting period.