



Research Assessment Exercise

RAE 2021 Summary report

Authors:

Vice President for Research, Annika Stensson Trigell
and Senior Advisor, Erik Fahlbeck

Table of Contents

PREFACE	5
EXECUTIVE SUMMARY	6
SAMMANFATTNING	8
INTRODUCTION	10
OBSERVATIONS AND RECOMMENDATIONS AT PANEL LEVEL	13
Strengths, weaknesses and general observations	13
Recommendations for panels and ideas of increased quality	13
MAJOR FINDINGS AT THE DEPARTMENTAL LEVEL	15
Strengths and weaknesses	15
Quality and quantity of contributions to the body of scientific knowledge	15
Follow-up from previous evaluation	16
Viability of the research environments	16
Faculty situation and recruitment strategies	18
Leadership and collegial structure	20
Interaction between research and teaching	20
RECOMMENDATIONS APPLICABLE TO THE WHOLE OF KTH	22
CROSS-PANELS AND COMMENTS ON IMPACT, RESEARCH INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT	23
Impact within the nine panels	23
Cross-panel on impact	23
Research infrastructure within the nine panels	24
Cross-panel on research infrastructure	25
Sustainable development within the nine panels	26
Cross-panel on sustainable development	27
REFLECTIONS ON RESULTS	29
Internal funding within KTH	29
High dependence on external resources	30
Academic leadership	30
The recruitment process	31
Administrative issues	31
Untapped potential	31
Gender and diversity	32
Infrastructure	32
NEXT STEPS	33
INVITED EXPERTS	35

Preface

The report you are now holding in your hand is a summary of an important part of the KTH quality system for research. The KTH Research Assessment Exercise (RAE; previously held in 2008 and 2012) is based on self-evaluations from engaged researchers at the university, and evaluations of peers, during 2020 and 2021.

In August 2021, a large number of invited national and international experts made digital visits to KTH in order to review and evaluate KTH's research. Based on nine subject-based panels, three cross-panels for infrastructure, impact and sustainable development, as well as complementary data and personal meetings, the 90 experts have summarised their observations and recommendations across twelve reports. You can find the summary of their recommendations along with accompanying reflections in this booklet.

The RAE 2021 results and this report provide KTH with valuable insights into how we can further develop KTH's research, in both the short and long-term. The results are of great value for the quality of research at KTH and for our future competitiveness. Hopefully, we can all use this report as a document to return to and lean on, in our joint work towards making KTH research better. It is both utterly important and inspiring that we use these results to improve and identify possible development areas and produce action plans for the future development and enhancement of the quality of research at KTH.

Finally, I would like to thank our external reviewers, the coordinating team behind the KTH Research Assessment Exercise and a special thanks to Annika Stensson Trigell, Vice President for Research, and the person scientifically responsible for RAE 2021. And, of course, thanks to all the rest of you for your commitment and input into this extensive and important work.



Sigbritt Karlsson, President of KTH Royal Institute of Technology



Sigbritt Karlsson, President of KTH.

Executive summary

RAE 2021 is the third of its kind at KTH. It is part of the KTH quality system for research, and its original intention was to evaluate research at KTH in 2020, but due to the pandemic it was postponed until 2021 and, like many other arrangements during this period, was conducted digitally.

As a university KTH strives to improve quality and relevance. One fundamental part of this work is to open our ambitions, organisation, and results to evaluation by international peers and to learn and be stimulated by assessments, such as RAE 2021. We are convinced that we learn a lot from colleagues, whether they are active at other universities or in other parts of the society.

The focus for this particular RAE is on continuous improvement of the quality of research activities at the departmental level, rather than ranking the scientific output of each unit of assessment per se. The work focused on aspects of fundamental importance for scientific performance. The 29 departments at KTH were grouped into nine subject-based panels. In addition, RAE 2021 included three cross-panels, focusing on how KTH works and performs within impact, research infrastructure and sustainable development.

In May 2021, the 90 evaluators, mainly from abroad, received the self-evaluation from the respective subject-based panel (or other relevant documentation for the three cross-panels). In addition, each expert panel had a start-up meeting in June. Furthermore, informative videos from all departments and major research infrastructures were distributed, and all experts were offered the opportunity to ask for additional information. This led to the intensive digital peer-review week, 23-27 August, 2021.

The overall impression from the evaluators is that research at KTH is at a very high international standard and is of high relevance to society. In all nine subject-based panels, the experts identified research of international excellence, and honoured both the societal collaboration and the impact that KTH research has, both within academia and industry, as well as for society at large. They were impressed by the performance of many of the research groups at KTH, the general level of research infrastructure and the potential to contribute to sustainable development.

The evaluators were explicitly asked to identify areas where KTH can improve in the future. One observation they made is that research at KTH is most often anchored in a vivid scientific, “bottom-up” driven process, which they honoured. Simultaneously, they also observed shortcomings in strategic planning and implementation of such strategic plans when they exist. On the one hand, the academic leadership at many of the individual departments is praised but, on the other hand, the experts identified what can be interpreted as a lack

of coherent academic leadership at various levels within KTH. One of the potential improvements is therefore to continue to work on the challenge of combining successful “bottom-up” based scientific engagement, with more long-term, “top-down” initiatives, especially related to internal funding, multi-disciplinary collaboration, scientific renewal, recruitment, and research infrastructure.

One identified challenge relates to the high dependence on external funding. Within the current Swedish research system, each university with successful research groups will over time experience an increasing share of external funding of research, research infrastructure and doctoral students. In almost all the nine subject-based panels, the evaluators pointed to a risk of becoming too dependent on relatively short-term, time-oriented research funding, where the research topics can be formulated by other actors or, in other words, they observed that this issue represents an increased challenge for financing “blue-sky” research which enables researchers at KTH to decide on research topics independently. The increased demand on co-funding from many of the external funding providers has also resulted in stronger restrictions on internal funding resources for strategic priorities.

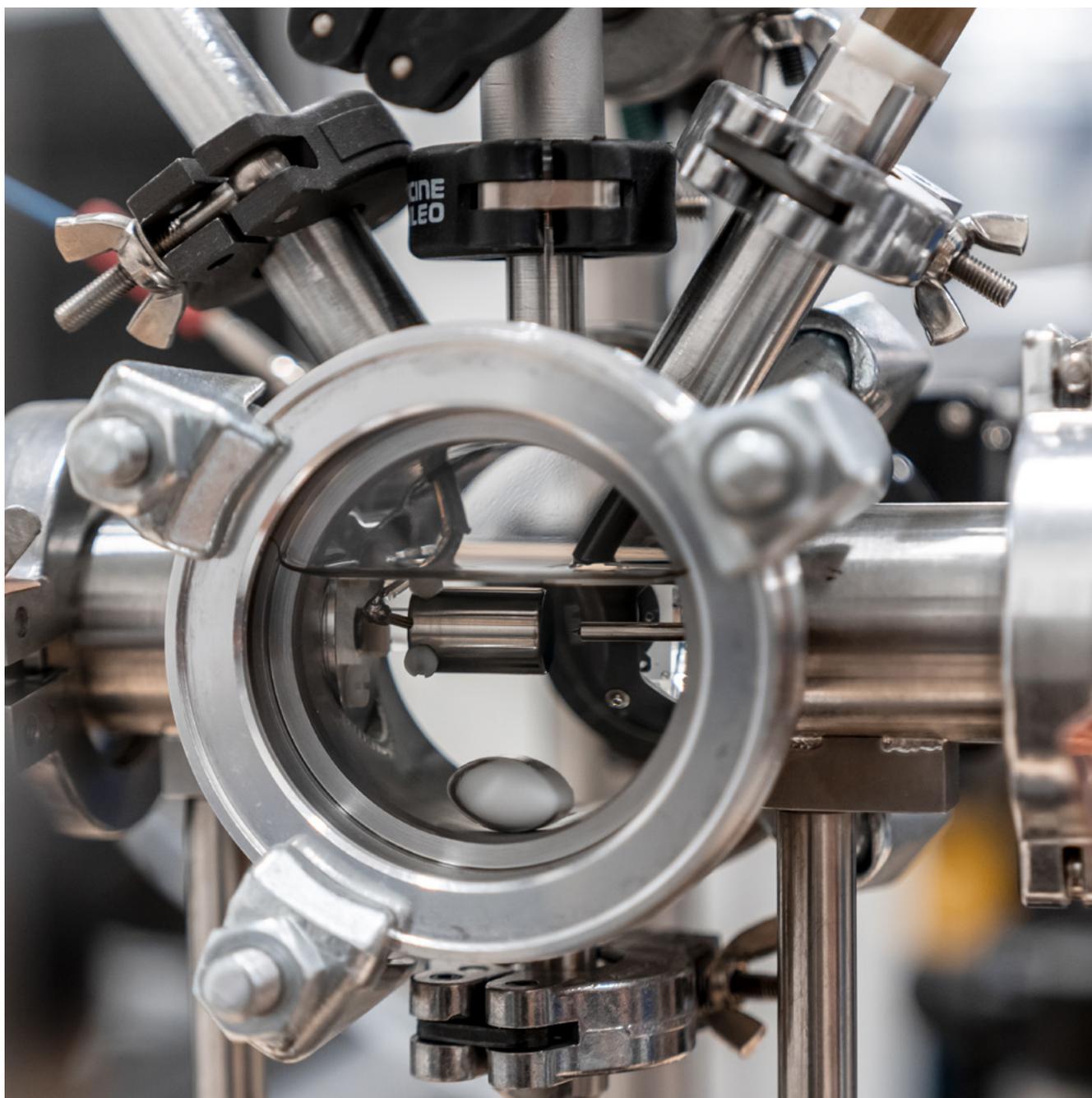
The evaluators also identified the potential for increased internal collaboration, and some research areas that may be at risk of being duplicated across panels or departments. Another area where KTH is recommended to improve relates to inter-, cross- and multi-disciplinary work, not least the work related to sustainable development. Furthermore, the experts give examples of departments that have been relatively successful in relation to gender and diversity, but the overall impression is that KTH needs to improve its efforts within these areas. In addition, there are many different recommendations for quality improvements; some departments are recommended to work more with publication strategies, others with renewal, the balance of academic positions, applying for more EU-projects, and so on.

The three cross-panels focusing on impact, research infrastructure and sustainable development were mainly impressed by the performance within their respective topics, but they also identified potential areas for improvement, such as clearer incentives for impact at the individual and departmental levels, fewer and more harmonised ways to achieve impact, increased internal long-term funding for infrastructure, stronger coordination of ambitions related to impact and sustainable development, and incentivising achievements related to sustainable development.

Broadly speaking, our evaluators have identified many areas where researchers within KTH perform very well and some areas where they are viewed as world-leading. Within most

panels the evaluators have observed an open, vibrant and prosperous academic culture. However, it is equally obvious that KTH needs to continue to develop some of its major internal processes, such as increased transparency in both internal funding and the recruitment processes. One major challenge for KTH seems to be to combine a more articulated academic leadership at central and school level with the strong and fruitful, “bottom-up” oriented culture at the university.

The evaluators have made many observations and recommendations for quality improvements, and here a short summary is provided. Hopefully this will make you curious about reading the specific recommendations within the area of your interest in the panel reports. The contributions by the evaluators are very much appreciated, and many activities have been initiated to make sure that the recommendations will be addressed accordingly.



Equipment in the Sustainable Power Lab.

Sammanfattning

RAE 2021 är den tredje upplagan av RAE på KTH. Den är en del av KTH:s kvalitetssystem och var ursprungligen tänkt att utvärdera forskningen på KTH under 2020. I och med pandemin sköts den dock upp till 2021 och kom i likhet med många andra aktiviteter under perioden att genomföras digitalt.

KTH som lärosäte strävar efter att höja kvaliteten och öka relevansen i kärnverksamheten. Ett viktigt led i detta arbete är att låta utvärdera vår organisation, våra ambitioner och våra resultat och att dra lärdom och bli inspirerade av utvärderarnas synpunkter. Vi är övertygade om att vi kan lära oss mycket av kollegor, oavsett om de är verksamma på andra universitet eller i andra delar av samhället.

RAE 2021 hade fokus på kontinuerliga förbättringar av kvaliteten på forskningsverksamheten på institutionsnivå, snarare än att rangordna forskargrupper. Arbetet fokuserade på aspekter som är av grundläggande betydelse för den vetenskapliga verksamheten. KTH:s 29 institutioner grupperades i nio ämnesbaserade paneler. Dessutom ingick tre tematiska tvärpaneler med fokus på hur KTH arbetar och presterar inom samhällsgenomslag, forskningsinfrastruktur och hållbar utveckling.

I maj 2021 fick de 90 utvärderarna, varav de flesta från andra länder, tillgång till självvärderingarna från de ämnesbaserade panelerna (och annan relevant dokumentation för de tre tvärpanelerna). Dessutom hölls ett inledande möte för varje expertpanel i juni. Utöver detta fick utvärderarna tillgång till informationsvideor från alla institutioner och större forskningsinfrastrukturer, och alla experter hade möjlighet att be om kompletterande information. Detta följdes av en intensiv utvärderingsvecka, mellan den 23:e och 27:e augusti 2021.

Granskarnas allmänna intryck är att forskningen på KTH håller mycket hög internationell standard och har stor relevans för samhället. I alla de nio ämnesbaserade panelerna identifierade experterna forskning som är i forskningsfronten. Man var imponerad av samverkan med övriga samhället och den påverkan som KTH:s forskning har, inom såväl akademi och näringsliv som för samhället i stort. De imponerades också av det samhällsgenomslag som många av forskargrupperna uppnår, forskningsinfrastrukturens generella standard och potentialen för KTH att bidra till hållbar utveckling.

Utvärderarna ombads uttryckligen att identifiera områden där KTH kan förbättra sig i framtiden. En iakttagelse de gjorde är att forskningen på KTH ofta baseras på en dynamisk vetenskaplig process initierad direkt från forskarna (s.k. "bottom-up"), vilket de lovordade. Samtidigt konstaterade de brister i den strategiska planeringen och i

genomförandet av de strategiska planer som faktiskt tagits fram. Å ena sidan berömde de det akademiska ledarskapet på många av de enskilda institutionerna, å andra sidan identifierade experterna vad man kan tolka som en brist på sammanhängande akademiskt ledarskap på olika nivåer inom KTH. Ett potentiellt förbättringsområde är därför att fortsätta arbeta med utmaningen att kombinera framgångsrik vetenskaplig forskning som initieras underifrån med mer långsiktiga initiativ ovanifrån, särskilt relaterade till intern finansiering, tvär- eller mångvetenskapligt samarbete, vetenskaplig förnyelse, rekrytering och forskningsinfrastruktur.

Det starka beroendet av extern finansiering lyfts som en utmaning. Inom det nuvarande svenska forskningssystemet kommer dock alla universitet med en stor forskningsvolym och med framgångsrika forskargrupper över tiden att erfara en ökad andel extern finansiering av forskningen, forskningsinfrastrukturen och doktoranderna. I nästan alla de nio ämnesbaserade panelerna pekade granskarna på risken att bli alltför beroende av relativt kortsiktiga, tidsbegränsade forskningsmedel, där forskningens innehåll formuleras av andra aktörer. De konstaterade att detta kan försvåra finansieringen av förutsättningslös forskning där KTHs forskare själva fattar beslut om forskningens innehåll (s.k. "blue sky-research"). Ökade krav på medfinansiering från många av de externa finansierarna har dessutom resulterat i ytterligare begränsningar i användningen av interna medel för strategiska ändamål.

Granskarna identifierade också möjligheter till ökat internt samarbete, och vissa forskningsområden som riskerar att dupliceras mellan olika paneler och institutioner. Ett annat område med förbättringspotential är tvärvetenskaplig, mångvetenskaplig och ämnesöverskridande forskning, inte minst relaterad till hållbar utveckling. Experterna gav också exempel på institutioner som arbetat relativt framgångsrikt med jämställdhet och mångfald. Det allmänna intrycket är dock att KTH behöver stärka sina insatser inom dessa områden. RAE 2021 innehåller också många rekommendationer som rör kvalitetsförbättringar på institutionsnivå. Vissa institutioner uppmanas att arbeta mer med publiceringsstrategier, andra med förnyelse, balansering av olika akademiska befattningar inom forskargrupper, ansökningar till EU-projekt och så vidare.

Utvärderarna i de tre tvärpanelerna med fokus på samhällsgenomslag, forskningsinfrastruktur och hållbar utveckling var överlag imponerade av KTH:s verksamhet inom sina respektive områden. Icke desto mindre identifierade de flera potentiella förbättringsområden: tydligare incitament för att arbeta med samhällsgenomslag på individ- och institutionsnivå, färre och mer samordnade sätt att åstadkomma samhällsgenomslag, ökad intern långsiktig finansiering av



Labbmiljö på SciLifeLab / Lab environment at SciLifeLab.

infrastruktur, starkare samordning av ambitioner relaterade till genomslag och hållbar utveckling samt att generellt uppmuntra insatser inom hållbar utveckling.

Sammantaget har våra granskare identifierat ett stort antal områden där forskare på KTH presterar mycket bra och många områden där de betraktas som världsledande. I de flesta paneler har granskarna observerat en öppen, levande och framgångsrik akademisk kultur. Samtidigt står det klart att KTH behöver vidareutveckla vissa processer, däribland öka transparensen både gällande intern finansiering och rekryteringsprocesser. En stor utmaning för KTH verkar vara att kombinera ett tydligare akademiskt ledarskap på central nivå och skolnivå med den starka och framgångsrika kulturen baserad på initiativ direkt från forskarna.

Granskarna har gjort många iakttagelser och lämnat många rekommendationer och denna rapport ger en kort sammanfattning av dessa. Förhoppningen är att du ska bli nyfiken på att läsa de specifika rekommendationerna inom ditt berörda område i respektive panelrapport. Bidragen från granskarna är mycket uppskattade och många aktiviteter har inletts för att se till att rekommendationerna tillvaratas.

Introduction

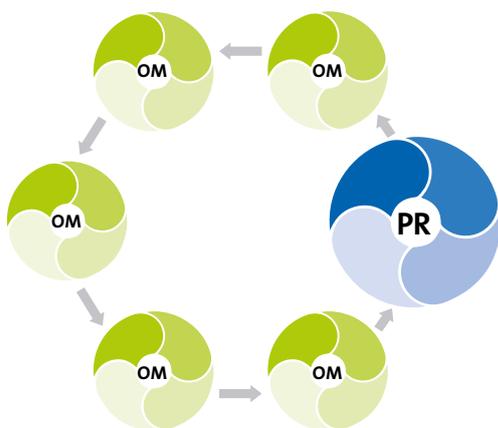
This RAE summary report is part of the Research Assessment Exercise (RAE) carried out in 2021 at KTH Royal Institute of Technology. The report is based on nine subject-based panel reports and three cross-panel reports. It aims to provide a short summary of the general recommendations and feedback provided to KTH, as concluded by the authors Annika Stensson Trigell and Erik Fahlbeck. Micael Stehr, Kristina Höök, Sebastiaan Meijer and Sebastian Stichel have also provided highly valuable reflections during the writing of this report.

In the self-assessments carried out, in preparation for RAE 2021, KTH's departments were asked to formulate strategies to increase the quality of research and the external experts have submitted recommendations to each department after their review. By grouping the 29 departments into nine subject-based panels, general cross-departmental recommendations have also been produced. The results are presented in nine panel reports that were published in November 2021. The three KTH-wide, cross-panels on impact, infrastructure and sustainability were also completed. The results are of great importance for the future development of KTH and play a key role in the quality assurance work.

The aim of RAE 2021 is to enhance the quality of research and research environments at KTH. The objective is to formulate visions and strategies that can lead to increased quality of research at KTH as well as greater impact. RAE 2021 is part of the KTH quality assurance system; see Figure 1.

Figure 1

KTH quality system
The quality assurance system has a six-year cycle with on-going monitoring (OM) and periodic review (PR)



- All 29 KTH departments were grouped into nine panels, within similar areas, see Figure 2.
- The departments within each panel wrote self-evaluations, describing how they have contributed to

the development and strengthening of the quality of their research, and strategies on how the quality of their research could be further improved.

- Experts were invited to review each panel, see Figure 3.
- Each of the nine subject-based RAE 2021 panels were assigned a dedicated coordinator and vice coordinator from KTH. The coordinators acted as a link between the departments involved in the panels, the panel chairs and experts; see Figure 3.

Figure 2

The grouping of departments into nine subject-based panels.

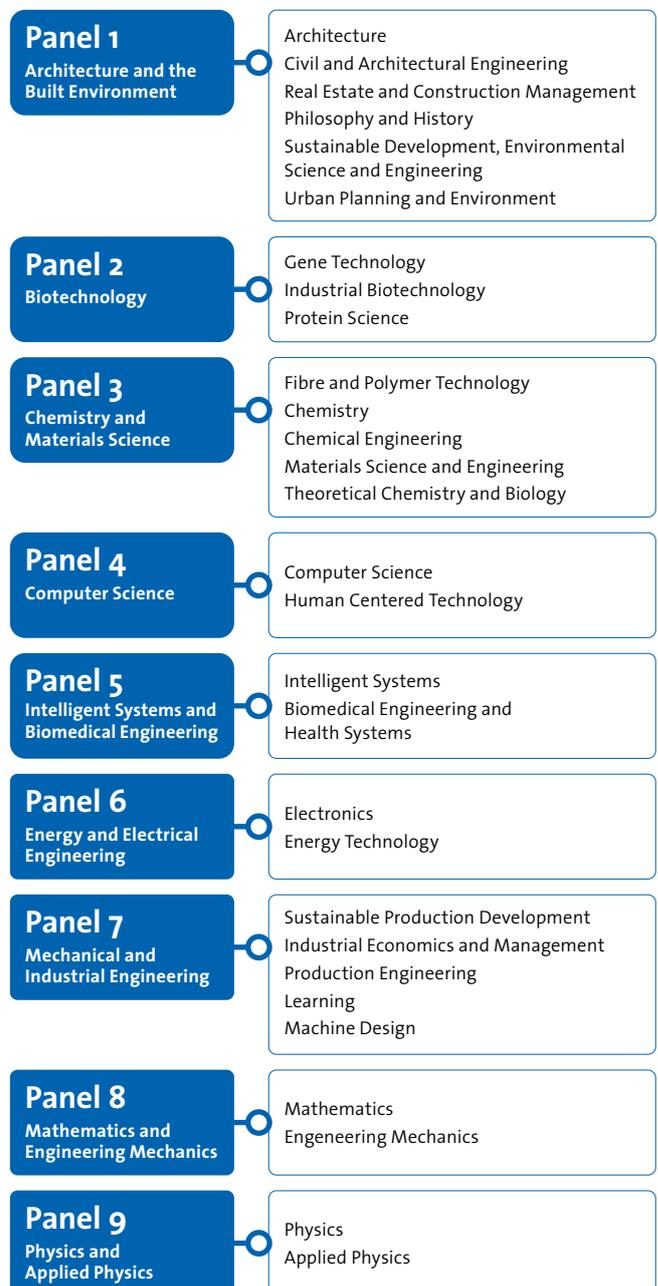
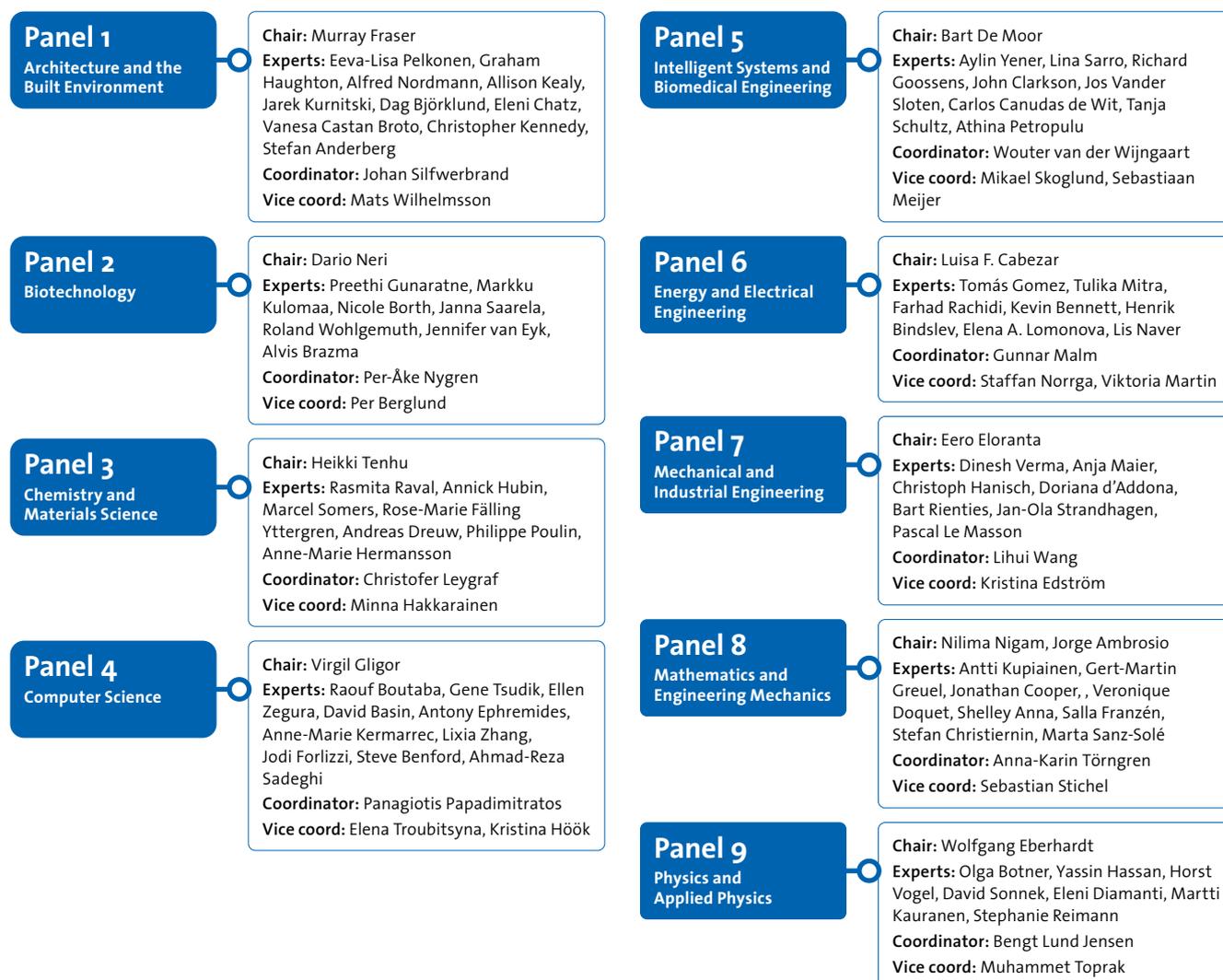


Figure 3

Chairs, members and coordinators of the nine subject-based panels.



KTH is dedicated to developing new knowledge and ground-breaking research for a more sustainable future. As a leading technical university, it is crucial to have up-to-date research infrastructure and to work in close collaboration with companies, research institutes and other public actors. Results and competence developed at KTH should also make a strong societal impact. The RAE 2021 therefore includes three cross-panels with the focus on important issues that are critical to the whole of KTH; impact, research infrastructure, and sustainable development. The experts and coordinators for the three cross-panels are listed in Figure 4.

The 90 invited experts in RAE 2021 come from many parts of the world. The geographic residence of all experts is summarised in Figure 5.

An overview of the RAE 2021 process is described in Figure 6.

KTH is a technical university, and therefore even if KTH conducts research across many scientific disciplines, they all relate to technology in one way or another. In this respect KTH is a “one faculty university”. KTH has one technical faculty, and does not divide research into faculties for e.g. humanities and arts, medicine, social science, etc. When the term “faculty” is used it refers to the staff at KTH holding the following positions: professors, associate professors, assistant professors and lecturers, also called “academic staff” in this report.



All 12 RAE-reports are published on KTH's web pages. More details on the RAE process can be found here.

Figure 4

Chairs, members and coordinators of the cross-panels.

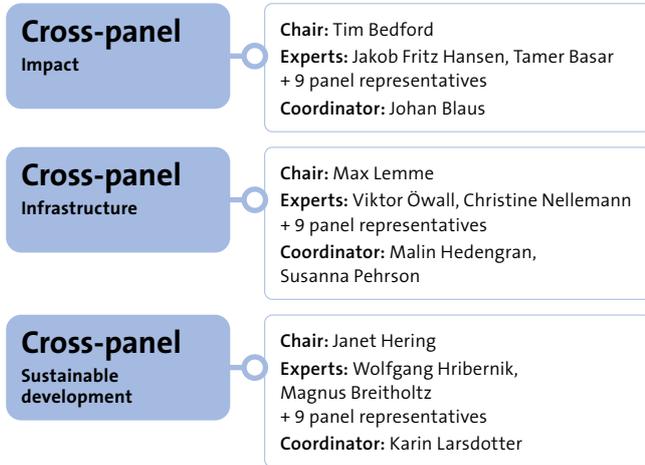


Figure 5

Geographic residence of invited experts in RAE 2021. Total number of experts: 90.

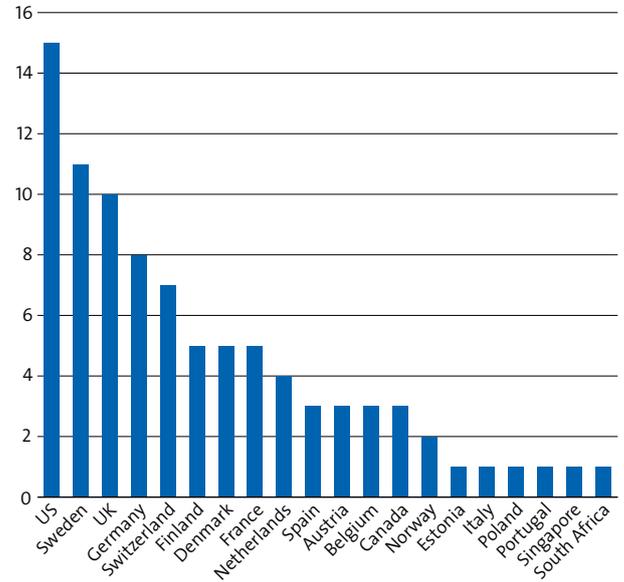
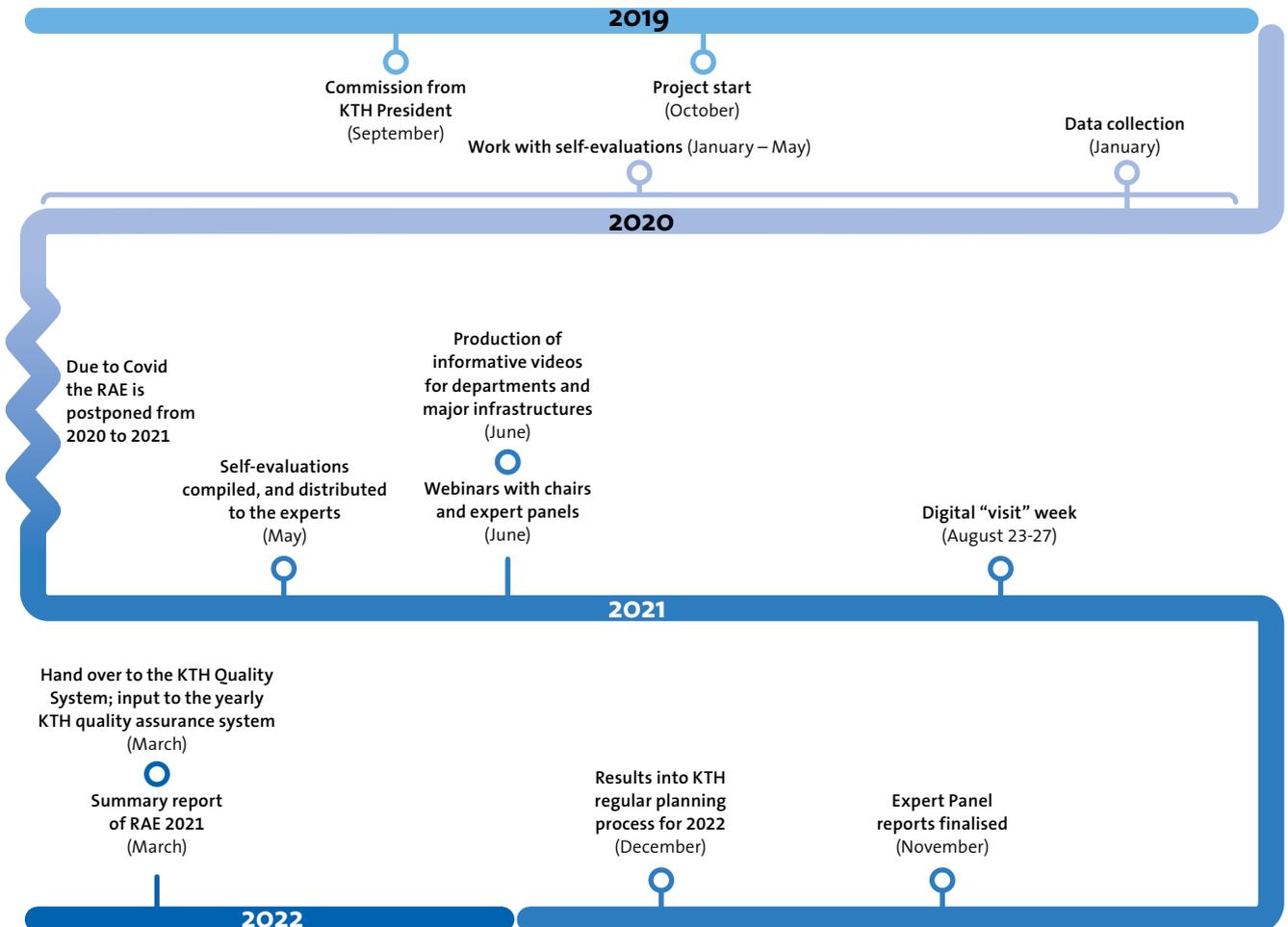


Figure 6

Flow diagram of the RAE process.



Observations and recommendations at panel level

This chapter presents a brief summary of the nine subject-based panel reports.

Strengths, weaknesses and general observations

Most of the panels noted that the research within their reviewed fields is “very impressive” or “very good”. Words such as “world-leading” and “excellent” are used in many cases, and overall the panels are impressed by KTH’s research. The academic staff are regarded as very enthusiastic and dedicated to their work, and KTH is well-connected with industry. Within the panels most departments also have relevant cooperations with international academic partners, while external funding levels are very high.

However, the majority of panels also point out that there is a lack of formulated strategies for research within their panel. A common recommendation is therefore to develop strategies (or “roadmaps”) identifying future research areas both for departments and panels alike.

Several panels have recommended an expansion of the number of academic staff. In some cases, it has been explicitly stated that this recommendation is a challenge for KTH as a whole, due to corresponding demands on internal funding.

Recommendations for panels and ideas of increased quality

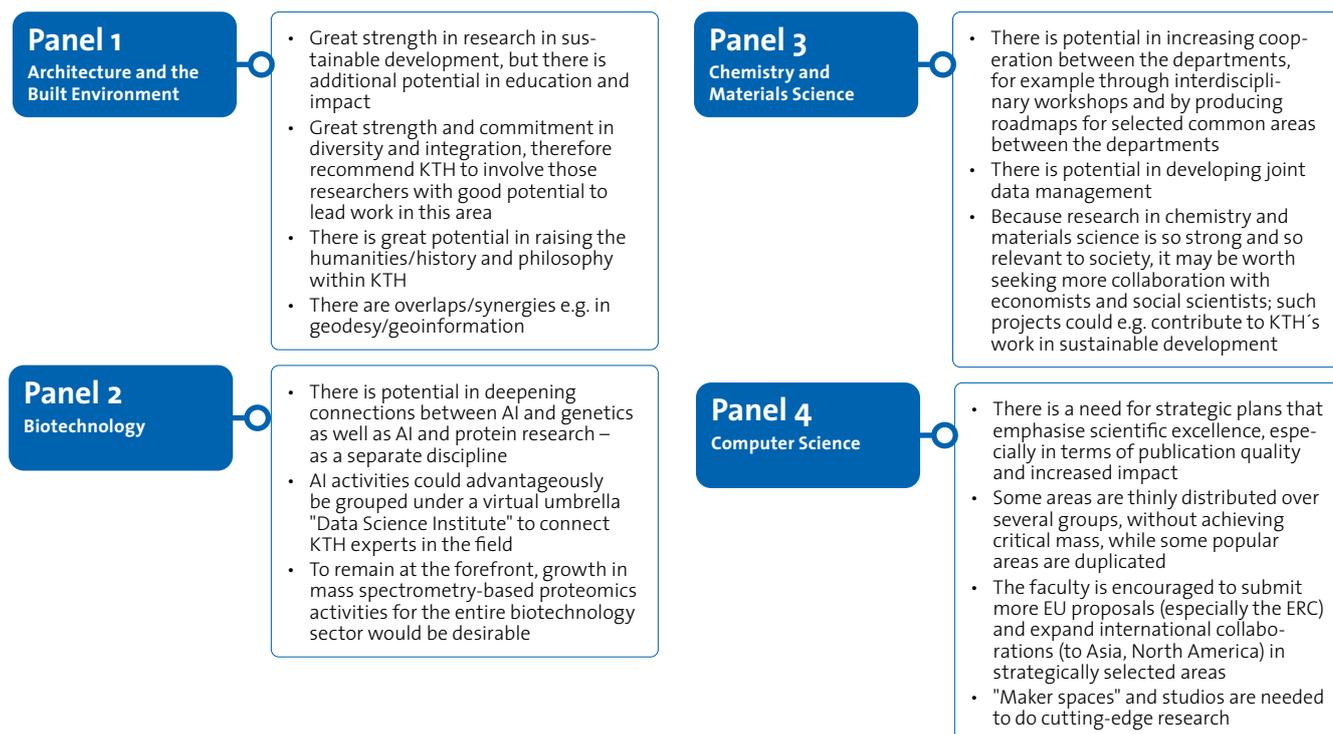
Several expert panels have pointed out that high-quality applied research is conducted in their field, and that this gives the panel great opportunities for collaboration with industry and/or society. Many panels are recommended to explore collaborations and opportunities that might lead to increasing both internal and external collaborations.

In several panels the experts noted that significant dependence on external funding is, on the one hand, a testament to the success of researchers in the panel’s field but also, on the other hand, limits opportunities to conduct long-term “blue-sky” research. In several cases, panels are recommended to work towards increasing “blue-sky” research. For an elaboration on this matter, see chapter on Reflections, starting on page 29.

The evaluators also identified a number of areas for improvement at the panel level. Some of the most important recommendations to the panels are listed in Figure 7.

Figure 7

A selection of recommendations for increased quality in research for each of the nine subject-based panels in RAE 2021.



Panel 5**Intelligent Systems and Biomedical Engineering**

- Establish common strategies and visions, not least to avoid being guided by short-term opportunities for external funding
- There is potential in increased collaboration between research groups within the same department, between departments within the panel but also with other parts of KTH
- There is potential in collaborating more with platforms and centres within KTH
- There is potential in also collaborating more with other partners, such as KI and the region, through the centres and to involve KTH Innovation more in that context
- Invest more in educating and stimulating the leaders of the future
- Increase efforts in collaboration and impact

Panel 6**Energy and Electrical Engineering**

- Expand collaboration within the panel and with the rest of KTH
- Establish pure research positions without teaching
- Consider offering the younger researchers more guidance, support or mentorship
- Identify a potential flagship project, a major visionary project involving the entire panel

Panel 7**Mechanical and Industrial Engineering**

- There is potential in comparing the departments' strategies and plans to be inspired by each other
- There are several very strong areas and, if the departments collaborated on a future-oriented positioning, they could strengthen each other
- Digitalisation and sustainability are common themes for the departments within the panel, so concentrate further on these themes
- Review research areas within the entire panel; there is a risk of fragmentation
- The IRIS initiative, which was created as a result of RAE 2012, and which is partly aimed at the type of collaborations mentioned above, has not developed as well. There is a great need for renewed energy, a proper project plan and more concrete goals for what is to be achieved
- LES could be a leading driving force for empowering student-centred innovative design at KTH

Panel 8**Mathematics and Engineering Mechanics**

- Get a better overview of the workload of the faculty and distribute the responsibility for teaching more evenly
- Encourage employees to take sabbaticals to strengthen relations internationally and with industry and society
- Try to develop a more functional administrative support, not least with regard to supporting the writing of (larger) research applications
- Define and develop a strategy to identify new research areas

Panel 9**Physics and Applied Physics**

- Develop a strategy to replace retired staff and attract young talent
- Investigate the potential of increased collaboration with SU, not least in education at AlbaNova
- Work strategically with funding for research infrastructure, including the maintenance of technical staff

Major findings at the departmental level

This chapter describes a brief summary of the major findings regarding different aspects important for the quality of research for the 29 departments. In general very positive feedback has been given directly to each department, see the respective panel reports (links to the reports can be seen on page 11). The main recommendations regarding research profiles, strategies and recommendations for strengthening the department are similar to comments at the panel level.

Strengths and weaknesses

The overall impression from the experts is that they were impressed or sometimes highly impressed by KTH research. Within all panels, experts observed research of very high quality, and for almost half of KTH departments the evaluators found groups with research that were commended as “world leading”, “excellent” or of “a very high standard”.

The experts also noted that researchers at KTH often have a strong, or very strong, collaboration with relevant industries, the healthcare sector, or other parts of society, and that research at KTH is highly relevant to society at large. For many departments this was linked to an observation that the academic staff at KTH are engaged, and that many research groups are driven by strong “bottom-up” initiatives.

However, all panels also recognised departments lacking strategies, and identified departments with subject overlaps. In addition, they noticed the potential for more collaboration within individual departments, within the panel or across KTH. The lack of strategy, or lack of roadmaps, was not only noticed for departments but at all levels within KTH and was sometimes expressed as “gaps between ambitions” at the central and departmental levels e.g. related to sustainable development, or the integration of the work with platforms within KTH. Within all panels, there were also comments about the lack of strategies or roadmaps at departmental level and/or school level.

Even though the overall impression about the quality and relevance of the research at KTH was clearly positive or in several cases very positive, many of the panels also found that individual departments at KTH could do even better, e.g. make a greater impact and reach further with efforts to improve sustainable development within the organisation and through its research, and to increase efforts in relation to multi- and cross-disciplinary research, for example by promoting internal collaborations that might increase the future quality of research and competitiveness.

Quality and quantity of contributions to the body of scientific knowledge

In the self-evaluations, each department was asked to describe both its quality and quantity of contributions to the body of scientific knowledge. A selection of publications that the department wanted to highlight was listed, as well as a

critical reflection on the department’s bibliometric performance and publication strategy. Illustrations of the number of fractionalised publications (divided into peer-reviewed articles and peer-reviewed conferences) from the department, for each year from 2012 to 2020, were provided. Both the publication impact and journal impact ratings from the databases WoS (Web of Science) and Scopus were presented for these years. Co-publication, an important indicator of collaboration, was presented as a 3-year moving average of the percentage of all publications, categorised according to both Swedish non-university and international collaborations, and also by source (WoS and Scopus). The panels were asked to assess the quality and quantity of contributions to the body of scientific knowledge of the department as well as their engagement in national and international research collaboration within academia and its outcomes.

In general, the assessment is excellent. According to the panels, 22 of the 29 departments show a very strong publication track record, with high impact publications in a variety of top international journals. Most panels state that KTH research production is impressive in both quality and quantity as indicated by consistently high positions in global rankings of academic subjects, and that KTH is a major contributor to leading journals. It is often mentioned that the academic staff are well-known and recognised leaders, an indicator of the high international reputation of the research groups. Many of the collaborative projects are distinguished and include peers from other universities who are at the forefront of research in their fields and many of the articles involve international co-publishing. There are also examples of specific researchers whose work has a particularly strong international focus.

Some departments host highly ranked international scientific journals, with staff such as Editor in Chief or Editor. It is common that academic staff from KTH also serve as board members and guest editors in numerous international scientific journals. They contribute with many invited plenary and keynote talks, memberships of research councils, learned societies, and by serving on evaluation committees for research councils and faculty positions, both domestically and internationally. KTH has also demonstrated its on-going leadership in project coordination for research programmes of considerable size.

In one example, according to the evaluators, this is the result of a deliberate strategy, supported by the overarching KTH vision for research excellence. The division they refer to supports their researchers by inviting editors from top-ranked journals to speak for the division members. This is just one element of creating a positive or upward spiral, where international exposure and reputation create new opportunities for research projects and collaborations and attract top researchers to their labs. Conversely, faculty members conduct research visits and internships at KTH's external collaborators.

One department stands out in the review by, in addition to its publication track-record, being exemplary in both engaging the scientific community at large and in conducting its dedicated communication activities. This panel believes that it would be almost impossible to do better, not only for dissemination activities, but also in terms of national and international collaborations.

For another department in particular, the panel mentions that it is difficult to make direct comparisons of both the quantity and quality of scientific outputs due to the wide range of disciplines within the department and their differing publication practices.

Four departments had similar remarks stating that information about impact factors may not always be useful in evaluating the contributions, as the leading journals in the respective disciplines are often interdisciplinary fora.

Six of the departments are recommended by their panels to undertake a concerted effort to further increase the quantity, and indeed the quality, of publications. For example, there exist departments where the publication record is mixed. Some academic staff publish in top-tier venues, whereas others favour lower-ranked, less selective, and more specialised (e.g. workshop) venues with relatively low visibility. For these, it is recommended that a strategic plan is set up that emphasises scientific excellence, particularly in terms of publication quality, and added impact. As a further suggestion, engaging more heavily in European projects is recommended, which can offer opportunities for involvement in highly interdisciplinary international consortia, such as via participation in large-scale initiatives and actions. These could form a strong vehicle for increasing collaborative research outputs both in the short and long-term.

Almost all departments show a clear engagement in international cooperation. This can be seen both in their research activities and in the quantity of publications with co-authors from other countries. For example, the panels noted that in some departments more than 70% of all research publications were achieved through international collaboration.

As one panel states *“All divisions in this department are fully international in all possible academic respects.”*

Follow-up from previous evaluation

To emphasise the importance that these types of research assessments have on the overall quality of research at KTH, the departments were asked, in their self-evaluations, to both describe and assess how recommendations and other outcomes from the RAE 2012 have been utilised or implemented, what measures have been taken, and what they resulted in. In other words, they were asked how the work of RAE 2012 has been implemented and where the departments are today. The expert panels reviewed this follow-up process during the peer-review week.

According to the evaluators, the majority of departments had positively addressed the recommendations from RAE 2012 and the expert panels congratulated them on, in many cases, successfully moving departments into a much stronger position. One highlighted example is incentives to increase and enable more interdisciplinary work through several large research programmes. Also, some departments have addressed previous reorganisation recommendations, which have made them stronger.

About one fifth of the departments have some remaining recommendations to address from RAE 2012, for which the expert panels have recommended that they should consider, in order to enhance the future quality and competitiveness of research.

Viability of the research environments

Many aspects are important for the viability of research. One of them is the funding situation. The departments were asked, in their self-evaluations, to describe and assess the department's internal and external funding sources for research. For each department, a diagram was presented showing the sources of research income from 2012, 2016 and 2020. Departments were also asked to reflect on what developments could be discerned, and which critical factors could be observed. The expert panels were explicitly asked to comment on internal and external funding, the current status and strategies for the future.

Many panels said that they were surprised to hear about the highly competitive nature of academic salary financing within KTH and Sweden generally. One panel recommended that KTH should consider pooling funding together to finance research projects with bold visions. If used intelligently, internal research funds could seed or leverage other external funding schemes, which may improve the flows of funds to the department, and also ensure that a higher level

of quality research is produced. One of the panels also advised their departments to consider “strategy” more as *“what is needed for something that we wish to do in the future”* instead of *“something that is imposed on the team top down”*.

The panels stated that almost half of all departments have experienced a significant expansion in their research budget since 2012. This expansion has been primarily financed by grants from external sources. This is a clear acknowledgement of the excellence of the researchers, and the research conducted at KTH.

Some of the departments however, according to the experts, have shown a more modest increase in research funding since 2012. Often this relates to those departments operating in an academic field in which there is relatively little money available for research grants. The experts noticed that the dependence on external funding implies that research and its funding also depends on political decision-making, where some research areas have received less funding, while others have received more.

Many departments have been very successful in receiving both national and EU grants. The most significant funding sources include the major Swedish national research councils, some of the most central governmental agencies, private foundations, and the European Union. The funding from the research councils highlights, according to the expert panels, the competitiveness of KTH research, while the funding from governmental agencies is an indication of its societal relevance. The high number of industrial and scholarship-funded doctoral students also bears witness to the recognition and well-connectedness of KTH in the Swedish context. The evaluators also noted numerous examples of collaboration with many academic institutions and research-intensive companies. In some departments, private foundations represent the majority of this expansion in research funding since 2012.

The RAE experts also acknowledge that some departments have self-imposed a culture of pursuing highly competitive external funding with a long-term perspective i.e. projects with a lifetime of 5 years or more, from for example ERC, KAW, VR, SSF, Vinnova, WWSC, WASP, etc. For some departments, a recommendation is that they could develop further by applying for more EU funding. It is, for example, mentioned that ERC grants are under-represented given the extremely high quality of one of the departments.

It was also noted that many departments are heavily involved in several Swedish research centres and European initiatives. This is a major source for funding and provides coherence in research strategy within certain topics. Many panels therefore recommend that such initiatives are encouraged.

In some departments up to 70% of their research funding comes from external grants. While the success in winning competitive funding is recognised as a strength of the departments, this fact also highlights a potential vulnerability, as fluctuations in funding schemes or other unpredictable events may endanger the operations of a very successful department. The evaluators noticed that this considerable dependency on external funding also comes with a risk that departments follow research agendas set by others, and that funding opportunities could be focussed on applications, rather than method development and scientific renewal.

The need to secure co-funding for many of the externally financed research projects means that the internal funding from KTH is used for such actions, in detriment to investing in new ideas or more basic research. It has been noted that this unfavourable situation could result in a huge burden on the faculty, leaving it with insufficient “breathing space” required for developing and implementing long-term strategies and funding plans. Further, as national and international funding strategies change and evolve, agility is required to maximise grant success, which might be difficult to manage under such economically-strained circumstances. The internal funding model at KTH is therefore a critical factor for departmental viability highlighted by almost all panels.

Furthermore, the evaluators note that the ratio between external and internal funding for research can vary considerably between divisions within a department. This large spread has been identified as a challenge for departmental management.

Besides supporting teams and individuals in their funding efforts, and trying to encourage new collaborations within the department, the evaluators notice that many departments do not appear to have a joint vision and strategy for their future research agenda. The issue of restrictions caused by a limited availability of internal funding was stressed within many panels, and seems to be limiting the freedom of faculty staff and researchers in their pursuit of broader, “blue-sky” research agendas and projects. Many departments have been recommended to strive for more “blue-sky” research. A strong dependence on external funding is also challenging for meaningful long-term strategic planning, which can be especially aggravating when the timeline of projects at international facilities like CERN or FAIR runs over decades. The challenge of obtaining co-funding when applying for project grants for work at these facilities was emphasised as a critical issue for the fundamental science groups in particular.

Another important aspect for the viability of research environments is the academic culture. It is the core from which the quality of the research must grow, and it is also crucial to the viability of the research environment. When summarising the assessments of academic culture at KTH, the experts were impressed by the quality of work, the openness of communication, and the high level of scientific exchange and collaboration. They use phrases such as “*an enviable living academic culture*”, describing KTH as having a strong, inclusive and open culture with a vibrant and dynamic research community.

The evaluators highlighted the following important aspects for KTH culture: departments were assessed as being balanced and inclusive with flat organisation and easily-accessible professors, well-anchored, lively and productive, with strong cross-fertilisation between different subjects. Further common conclusions include: observing trusting relationships, having a well-established philosophy of sharing and supporting each other, and that KTH is a good workplace. One expert panel, however, mentioned that the struggle for external funding seems to affect the culture and morale of the department, with the younger academic staff in the worst position in this regard.

Faculty situation and recruitment strategies

The current faculty situation is another important aspect for viability. In self-evaluations, the departments were asked to describe the current staff, including the composition of research teams. Diagrams were presented of the staff headcount for different positions for the years 2012, 2016 and 2020, divided into women and men. Also, the perspectives of age, gender and career stage balance were commented on. The self-evaluations included a question on what steps that are, and will be, taken to develop and sustain a sound balance in these respects for the years to come (next 5-10 years). The department recruitment strategies regarding faculty, postdocs, researchers, and doctoral students were also described, as well as how equal opportunities are safeguarded. The expert panels were explicitly asked to comment on the current faculty situation and composition of research teams for each department, as well as on the proposed recruitment strategies.

There is a large variation in the current faculty situation for different departments, both regarding the number of staff in different positions, as well as gender composition across the departments. In many departments, there has also been a decrease of doctoral students in favour of hiring more postdocs.

Seven of the 29 departments were evaluated by the experts as being fairly balanced regarding senior and junior faculty

members and recently-recruited staff. The faculty situation is good and the size seems to be sufficient to pursue their specific goals.

Seven other departments are undergoing a massive generational shift, according to the evaluators. These range from departments with what can be described as an inverse pyramidal structure (i.e. more professors than young researchers and young assistant professors) to departments with many leading academics in the same age range, or sometimes a whole group of professors retiring in a short time span. The evaluators identified one department that, although highly successful, has suffered from a large decrease in the number of associate professors, assistant professors, adjunct professors and research engineers, and with an increase in full professors, resulting in a total of 21 fewer faculty members in 2020, as compared to 2012. During the same period of time, the number of postdocs increased by 18. Replacing staff with new postdocs and researchers keeps the body count the same, but the evaluators have stressed that this is no substitute for permanent academic staff. The department is still very top heavy in terms of the number of full professors approaching retirement. However, the department also has an excellent record in hiring faculty members with very high potential, as is demonstrated by its four ERC grants. The evaluators advise developing a carefully defined strategy, to balance faculty renewal with the identification of emerging and fading research topics.

In four other departments (where retirement was not a noteworthy issue), the balance between professors and junior faculty members shows some bias towards professors. In particular, the number of assistant professors is critically low in some departments, according to the experts.

The recruitment of adjunct professors was recommended by some panels as a strategically important way to connect complementary disciplines to the departments for a more interdisciplinary research approach. This recruitment also allows for strategic alliances to be formed with external partners. Some departments have been very successful in the recruitment of affiliated faculty members and adjunct professors, also with the purpose to manage the shortage of internal faculty staff, but the evaluators stress that this is not a sustainable solution in the long run.

Disproportionality between a low number of faculty staff and a high number of researchers has also been observed in three departments. This has differing consequences, according to the panels. In one department, many of the researchers have been able to attract external funding for a long period of time. They have also taken on teaching, supervision and even leadership duties, but still have limited prospects in obtaining positions such as faculty staff. This

lack of career path opportunities is a concern according to the evaluators. Another department has a large proportion of researchers to enable the heading of large national facilities and flagship projects. Critical mass is important here, in order to maintain an extremely high academic standing and to excel in productivity. This panel recommends not changing a “winning team”, but warmly encourages KTH to consider how to best ensure continuity for a system which serves as an international role model.

The expert panels also identified four departments where the number of faculty staff is remarkably low in relation to the needs for teaching, examination, and doctoral student supervision. A continued decrease in faculty staff numbers may also harm the capacity to develop competitive proposals for larger research projects. The reason for this, according to the evaluators, is that new positions for faculty staff at KTH require corresponding internal research funding, which makes it difficult to create faculty staff positions based solely on external funding and teaching.

In some departments, recruitment since RAE 2012 has been very effective with the appointment of professors who have proven to be leaders in their respective fields, capable of driving real change. The effect of these appointments is positive and clearly visible in recent research developments. According to one panel, the procedures followed for hiring were performed at the highest standard and one panel mentioned that they have no doubt that this professionalism will continue in the future. This panel also made recommendations as to new research areas to consider for future positions at one department. For general comments on the recruitment processes at KTH, see chapter on Reflections, starting on page 29.

For some departments the faculty is young, and no retirements are expected to happen in the foreseeable future. Thus, growth will probably only occur if KTH makes new positions available. Still, one panel urged the departments to formulate a clear strategy for new recruitment that would further enhance ongoing effort and build strength in maintaining “*sustainable excellence*”. For other departments, the most important near-term recruitment challenge is replacing some key professors nearing retirement, according to the evaluators.

In general, one expert panel reports that KTH recruitment strategies are two-fold. There is one for doctoral students, postdocs, and researchers, whom are usually funded by specific project financing with very specific qualifications, and another strategy for academics going through the tenure-track system within KTH. The departments attract guests and researchers at a high rate, and it is internationally visible as an intellectually vibrant place.

Some panels identified a challenge in finding continuity in recruitment, due to the limited availability of faculty positions guaranteed with internal funding, coupled with the difficulties in recruiting doctoral students and postdocs. According to one panel, the problem regarding doctoral student recruitment was related to the legal requirement to be able to guarantee doctoral funding for 4 years before the doctoral student position is made available to candidates. One panel observed this as being important, since having a limited number of doctoral students may impact upon the innovative capacity of the department, given that they often have the time and space to take on daring and risk-intensive projects. The experts suggested that industrial doctoral students were the most obvious route to increasing doctoral student recruitment.

In some departments, decreasing numbers of doctoral students could, according to the experts, be a threat to teaching from a long-term perspective, as they are involved in teaching undergraduate courses. Furthermore, technical support and maintenance of equipment are currently, to a large extent, the responsibility of doctoral students, and the evaluators do not consider this to be a sustainable long-term solution. Dedicated technicians are often available for more advanced and expensive instruments, but their employment situations require further consideration, according to the evaluators.

Recruitment of faculty staff is based on both teaching and research needs. The evaluators noted that the recruitment strategy of several departments focuses primarily on recruiting associate professors to increase the number of lecturers. According to the experts, appointing these associate professors seems well-motivated, as it offers the opportunity to recruit new research leaders from outside, or for long-term researchers to obtain permanent faculty staff positions, which they are often well-qualified for. However, it was observed that some departments recruit lecturers whom are supposed to focus entirely on teaching which, according to the evaluators, is questionable for such a strong research department, since it seems to go against the university ambition that “teachers are researchers and researchers are teachers”.

It was also noted that recruitment strategies for several of the departments largely rely on their excellent research atmosphere, both in terms of scientific excellence and international reputation as well as the friendliness and open-mindedness of its current members. Some evaluators stressed that recruitment of the best talents is particularly difficult if start-up packages are not competitive with the best peer universities. However, benefits such as research freedom, personnel career development training, and the possibility of parental leave also play an important part in attracting recruits, according to the experts.

One role model was identified by one panel; a department that has an excellent record in hiring faculty staff with very high potential, as demonstrated by its four ERC grants. Besides addressing clearly identified research areas, the hiring of junior faculty staff by sensibly using the criteria of having ERC grant potential is encouraged in this case.

The recruitment of female researchers at technical universities is historically difficult, and a better gender balance is aimed for, as noted in many panels. Nevertheless, it has been observed that several departments have very few female faculty staff. These departments are well-aware of their poor gender balance and consider it to be a major weakness. For one of these departments, a central plan of action was previously formulated with 20 specific recommendations for improvement.

For another department, the evaluators noticed evidence of a constructive and thoughtful recruitment strategy in terms of the appointment and support given to female academics. The experts commented that it is remarkable that all the full professors in that department are female, unlike any other in the world, according to their report. The experts noticed this to be an excellent start in terms of inclusivity and diversity, and that now would be a good time to apply this appointment policy to bring in more faculty staff from other social groups that are not usually represented at full professor level due to ethnicity, disability, or other personal characteristics. Awareness of this issue was mentioned by several panels.

Leadership and collegial structure

The organisation of daily work and the leadership within it and among colleagues are both important aspects of academic progress. In RAE 2021, experts were asked to consider the leadership and the collegial structure in each department. Two panels chose not to respond at departmental level. All panels did, however, comment on leadership in one form or another at different levels within the university. For more general reflections on such matters, see chapter on Reflections, starting on page 29.

Most of the panels provided reflections on leadership and collegial structure from an organisational perspective. The flat, open and collegial organisation at departmental level was often mentioned. The structure of departments and their work were compared to other international universities, and the experts concluded that they are either similar, or the evaluated KTH departments have otherwise chosen an expected organisational form, with notions of traditional line organisation and expected matrix initiatives in a few cases.

When commented on, the collegial structure at KTH is seen as open, with present and active professors and with traditional forms of academic dialogue.

Leadership at departmental level was also commented on from a functional perspective for most panels and for departments within them. The most commonly reported evaluation is that the leadership at departmental level is very good or excellent, with comments such as; *“leadership works well for all departments”*, *“Excellent leadership with extremely well motivated and committed researchers”*, *“The leadership of ... is excellent, leadership and collegial structures are managed professionally at ...”*, and *“able, enthusiastic and pro-active leadership”*.

Even if a clear majority of the departments are viewed as being (highly) positive, there are also several critical comments. These include reflections for individual departments on issues such as potential shortcomings in relation to future leadership, a need to improve on being part of bigger projects, and the potential for being bolder in future research ambitions. In a few panels gender issues are commented on, in relation to leadership. For one department the evaluations notice: *“While the organization and the leadership structure are rather typical for any university department of this size, it is astonishing that – despite what is clearly a gender-balanced staff team – so many of the leadership and management responsibilities are held by women. This kind of imbalance in administrative responsibilities may hinder the academic career of these female staff members. Furthermore, that many of these women in leadership positions do not even have faculty staff positions is another indication that the current structure is far from desirable, and so the department should look into this matter.”*

The gender balance in relation to leadership is commented on for one additional department, where it is seen as being good.

In various parts of the nine subject-based reports other aspects of leadership are commented on. These evaluations commonly point to weaknesses in strategic planning and a lack of roadmaps to fulfil such strategies, where they exist. There are also a number of comments on the lack of coordination and the potential for increased collaboration; see chapter on Reflections, starting on page 29 for additional reflections on such issues.

Interaction between research and teaching

The connection between research and education is the foundation of a university. The expert panels found that KTH faculty members thoroughly enjoy teaching and view the combination of research and teaching as an essential part of being a faculty member at a university. Additionally,

it was noticed that many of the topics that the staff have expertise in are also important for the students participating in the KTH educational programmes, their future employers and society in general.

The vast majority of the departments (20) were judged by the experts to have a clear synergy between research and teaching, meaning that students are exposed to research work in the department and can contribute to it directly. As a consequence, KTH appears to foster a healthy recruitment environment with a high reputation internationally. This commitment is also shown in a willingness to publish about pedagogy in engineering science.

In many cases, a direct and positive connection between research and teaching at all three levels i.e. Bachelor, Master and PhD education, is exemplified in the reports. Course materials are often updated to reflect developments in relevant research fields.

Nevertheless, it has been recommended that seven of the departments should increase their collaboration between research and education. One of the suggestions is to engage doctoral students more in teaching, in the capacity of assistants, something that would benefit those wishing to better “learn their trade” in becoming academics. Another suggestion is that some staff should include students as active members of the research community. A third recommendation from the evaluators is to more clearly embed the student voice in design, (co)creation, and innovation. Furthermore, with a changing student population (and life-long learning), it is important to help KTH staff in building more inclusive, equitable and diverse learning experiences for all students, including doctoral students.

One of the departments is said to have too low a proportion of faculty staff in relation to the amount of teaching required. In this case, the evaluators believe that it is necessary to remedy this situation, if the department wishes to ensure high-level research whilst maintaining its “top-notch” quality in educational provision. The experts also noted that another department suffers from the fact that it is not well-represented in undergraduate education. One consequence of this is that they largely recruit doctoral students internationally.

Many of the panels also mentioned that close research collaborations with industry are reflected in the fact that teaching becomes societally relevant.

Recommendations applicable to the whole of KTH

In addition to evaluations of and recommendations to panels and especially departments, the nine subject-based panels were asked to reflect on areas of improvement for KTH as a university. The three cross-panels also included some general topics. This chapter summarises these recommendations. Some of these recommendations are also commented upon in the section with reflections on the overall outcome of the RAE 2021, starting on page 29.

Some topics are relevant for all, or almost all, of the nine subject-based panels. They are listed below.

- Most panels identified the internal funding model at KTH as a challenge and they recommend that KTH rethinks how internal funds are used. One common comment is that the balance between internal university funding and external funds to cover salaries, infrastructure and other research expenditures needs to be reconsidered. Many of the panels recommend that KTH increases the share of internal funding, in order to stay attractive and to enable better long-term conditions for researchers, including better conditions for “blue-sky” research.
- Many panels also say that the model for internal allocation of research funding that KTH applies is not transparent and therefore recommends that KTH works with its model of internal allocation in order to make it easier to understand.
- In many panels, the evaluators reported that the interviewed faculty staff indicated that administrative support within KTH has various shortcomings and is felt to be expensive. Further, it was suggested that administrative support is adapted to really help researchers in their daily work, while some experts suggest a more decentralised administrative support structure.
- Almost all panels highlighted the employment process at KTH and concluded that it is perceived by most of the interviewed faculty staff as being too slow. Most panels recommended that KTH works on improving the hiring processes.

In addition to these common recommendations, there were other topics that in various forms were identified by a few panels. One such issue relates to the strong and beneficial collaboration with industry, and other external actors such as the healthcare sector. Some panels identified the potential for improvements in this area, even if it is seen as functioning well today. One panel states: *“There are very strong initiatives in valorisation that can be combined into a more coherent and even stronger proposition for fast track to innovations in most disciplines, but according to this panel opportunities are abundant, especially in healthcare.”* Related recommendations for KTH are to *“Retain the good and open spirit of collaboration with Industry”* and to develop clearer strategies for spin-offs. Most panels noticed that KTH has many strong research areas and excellent collaborations with society; in various forms, several panels recommend that KTH uses these

strengths to improve its work in relation to societal missions. One panel concludes: *“As the global/societal challenges are becoming increasingly complex, we recommend that KTH adopts a broad thematic focus on Socio-Technical Systems as a context for its engineering and technology excellence”*. Another panel recommends that KTH focuses more on municipalities, not only at state level and legislation, in order to increase the societal impact of research at KTH.

Other issues raised as recommendations by individual panels are that; *“KTH is recommended to take infrastructural investments on the list of crucial topics to sustain the competitiveness of the university”* (a similar notion is given from the cross-panel of infrastructure); KTH ought to work more on clarifying central initiatives, expressed as a need for *“better diffusion of top-down policy plans”* to overcome what is perceived as gaps between various levels within KTH; that there seems to be a lack of strategic visions; *“Increase EU funding participation by identifying internal administrative and financial barriers”*; clarify the pathways for an academic career within KTH and look more carefully at the issues of fragmentation of competences.

Cross-panels and comments on impact, research infrastructure and sustainable development

This chapter summarises the comments from all nine subject-based panels on the topics of impact, research infrastructure, and sustainable development. Each of these themes is followed immediately by a summary from each of the three cross-panels, for the respective topic.

Impact within the nine panels

The departments were asked to describe and analyse how their research is relevant and useful to society at large i.e. impact outside academia. Twelve impact cases were included in each of the nine self-evaluations for the subject-based panels to illustrate this. A description of processes or mechanisms to achieve increased impact and engagement in society, as well as the departments strategy for communicating the research results beyond academia were provided. The expert panels were then asked to assess the impact, as well as plans and structure for increasing impact.

For a clear majority of KTH departments, the experts were impressed or highly impressed by their societal impact, usually through numerous contacts and collaborations with industry, but also with public agencies and the healthcare sector. In a number of departments, the experts also highlighted an impressive number of spin-offs and patents.

The overall impression is therefore that the experts have observed that departments and researchers at KTH collaborate extensively with industry and society at large, that many groups also work with relevant or highly relevant research with actors outside academia, and that this tradition is obviously strong within KTH.

The panels also noted that most departments work well with the dissemination of research beyond academia, even if the comments in this area were not overwhelming and some noted that ambitions within their respective department for the external dissemination of research were similar to what one could expect in academia generally.

Even though the experts were clearly impressed by the work with impact at KTH, they also noted several areas for improvement. In many cases, they requested new strategies for impact at the departmental level. In some cases, they also asked for clearer support mechanisms, such as clearer guidelines for spin-offs, especially for academic staff that engage in such spin-offs.

In several cases the experts noted very strong and convincing impact cases from their respective departments, and often noticed that such impact cases can be used to improve information about activities in the department. In terms of impact, one common recommendation to departments within KTH is to work more often with information, the web and social media, both as a form of dissemination beyond

academia, to inform society at large and to increase the attractiveness of KTH e.g. as a basis for future research collaboration.

Cross-panel on impact

The overall impression from the evaluation of KTH's work with impact is that the evaluators are impressed. They recognise that KTH as a whole has numerous excellent examples of impact, not least among the impact cases included in the self-evaluations. They also recognise high ambitions within the KTH work on impact, including the initiative with the role as impact leader at school level and the strategic partnerships. At the same time as they honour KTH on the work with impact, they also noticed that most universities today develop their ambitions in external collaboration and impact and conclude that, if KTH wants to continue its strong position in relation to impact, KTH needs to continuously develop its activities in many areas.

Several reflections and recommendations are given in the report. Some of these recommendations are directed towards KTH as a university, some focus on the support structures of the university and some are directed towards schools and departments.

The evaluators conclude that:

- “The role of the line-organisation (KTH leadership and school heads) is to*
- Define strategy and development plans for the whole university*
 - Set the organisational structure for impact support and dialogue*
 - Develop incentive structures for both entities and individuals*
 - Qualify and further develop/prioritise the 18 impact pathways (or groupings of them)*
 - Develop a systematic feedback system (audit/quality system)”.*

The evaluators noticed that collaboration is well-represented in the existing development plan for KTH, but impact is not. For that reason, and others, it might be unclear what ambitions KTH as a university has in relation to impact, according to the evaluators.

In relation to impact support, the evaluators conclude that many different initiatives exist and also, in their perspective, further potential. They notice that the leadership at KTH has taken many initiatives and that the role as impact leader on the one hand is central, but at the same time enables diversified school priorities. They recommend KTH conduct an

evaluation focusing on the overall support mechanisms for impact, building on RAE 2021, the evaluation of strategic partnerships, the evaluation of impact leaders and the development project under UIIN. They especially mention the potential of KTH Innovation, to further contribute to the work with impact and they noticed that: *“The Innovation Readiness Level Framework developed by KTH and widely internationally used for coaching commercialisation ideas could be further developed in the impact work at KTH and in a revised form more widely used as an instrument for impact readiness and hence supporting the development of an impact culture.”*

They noticed that KTH, in its internal documents, describes 18 ways for impact and they noticed: *“There may be merit in a rougher classification, for example as simple as **industrial collaboration, spinouts, science and policy advice, standards, and public outreach**, within which the concepts of reach and significance of impact can be used.”* (bold added)

In the discussion of the need for, and positive effects of, a clearer understanding of the essence of impact at KTH and what KTH would like to achieve with its work on impact, they conclude that there is a need for some kind of measure or at least some form of stated goals. If such measures or goals are developed, it will also be possible to include impact in the systematic work with quality control and audit within KTH, which the evaluators recommend.

The evaluators have recognised that many researchers within KTH are well aware of issues related to impact and are also dedicated to work with impact, even if there exist different ideas of how societal impact should be understood. A clearer and stronger focus on how KTH centrally interprets impact can therefore guide the development of an even stronger and more harmonised internal support, as well as make it easier for departments and researchers within KTH to contribute to the fulfilment of the impact ambitions.

The evaluators conclude that almost no incentives exist for researchers in relation to impact. In more than one section, the evaluators comment on the lack of individual incentives, and they recommend that KTH develops various merits to be used internally e.g. in relation to academic positions and salaries. The evaluators recommend KTH to introduce incentives for departments to develop their work with impact. In addition to meriting work with impact in salaries and positions at KTH, it should also be recognised by awards and other kinds of celebration according to the evaluators.

The evaluators comment on several of the impact-related initiatives within KTH. They recommend that KTH continues to work with the role as impact leader, but they also point out that KTH ought to clarify this role, in combination with a recommendation that the schools within KTH also ought to

clarify their respective ambitions on what they would like to achieve in relation to impact.

KTH's strategic partnerships are recognised and honoured. At the same time, the evaluators conclude that KTH could develop this initiative further e.g. with a complementary role for schools meaning that schools could be given responsibility for certain partnerships. It is also recommended that KTH clarifies the ambitions of the strategic partnerships, both taken jointly and individually. Such a clarification could be guided by a reduced number of pathways to impact i.e. the individual partnerships could be specialised for various pathways to impact.

The evaluators recommended that KTH clarifies how the work with the global development goals could strengthen the work with impact and vice versa, and to consider ways to make further use of collaboration in relation to infrastructure and platforms, as a means to increased impact.

To summarise, the evaluators were certainly impressed by how KTH works with impact, and they describe KTH as a leading university in this area. But they also recommended that KTH continues to develop its ambitions for further impact and gave examples of potential improvements in a number of areas, to enable KTH to keep its strong position in the future.

Research infrastructure within the nine panels

The infrastructure and research facilities important for the research at departmental level were described in the self-evaluations and an estimation of what kind of investments are needed to ensure that the infrastructure remained internationally competitive. The expert panels were then asked to assess the important infrastructure and facilities for the respective department.

The overall impression from the nine subject-based panels on the infrastructure within KTH is very favourable. More than one third of the departments at KTH has, according to the experts, excellent or world class research infrastructure and almost all the others are seen as well-equipped. Within many of the panels, the experts were impressed by the research facilities within KTH. The experts did, however, find individual departments where infrastructure was not on a par with comparable peer universities.

In some panels the experts recommended that individual departments collaborate more within KTH. They identified potentials for a better sharing of research infrastructure between departments in the same panel and within schools, but also with departments in other schools.

In more than a handful of cases the experts noted that research infrastructure of high quality was also used in teaching, which was appreciated. This sharing between research and teaching was, however, also raised as a challenge from a research perspective in at least one panel, from the aspect that researchers might be restricted in their use of the infrastructure if it was also frequently used in teaching.

Another very common theme was the observation that investments into, and the maintenance of, research infrastructure was heavily dependent on external funding. This was addressed as an important challenge for many departments within KTH. The experts also highlighted the situation surrounding the skilled personnel necessary to run research infrastructure, whereby in several cases, they noted a shortage of permanent technicians. For many departments they saw this as a real challenge, and in several cases they recommended that KTH looks more carefully at the funding of technicians. Some panels noticed that it is often doctoral students that run important research infrastructure and saw this as a shortcoming in relation to maintenance and long-term development.

In many panels, the experts requested more strategic planning from KTH and its departments, to be able to continue to keep research infrastructure of a high quality. More internal funding was recommended in some cases, also for technicians.

Another issue noticed by some panels was the fact that research infrastructure that needs lot of space becomes costly, given the rental model that KTH uses today. KTH was, in some cases, recommended to reconsider, or at least look into, this issue.

The major impression from the experts in the nine panels was, however, that departments at KTH have access to very good research infrastructure and that the university is well-equipped in this area.

Cross-panel on research infrastructure

The overall impression from the evaluation of KTH's work with research infrastructure is positive and the evaluators noticed that research infrastructure at KTH is in general of high quality and importance. The evaluators are positive about the initiative with central funding of a limited number of facilities, called KTH Research Infrastructure, KTH RI. This initiative is recognised as important and significant, although the central funding is regarded as being too low. The evaluators are also positive about the fact that the initiative with KTH RIs is led by the Deputy President, and they noticed that the KTH leadership is well aware of the

importance of and challenges with the funding of research infrastructure, especially for a leading technical university such as KTH. They noticed that: *“National funding seems available in unpredictable ways, which means that future developments are opportunistic rather than strategic”*.

Even though the general impression of the evaluation is positive, the evaluators did identify a number of areas where KTH could improve its work on research infrastructure. Established KTH RIs are seen primarily as an outcome of a combination of external funding and active researchers and infrastructure directors, rather than as a result of a KTH-wide strategic choice: *“The panel understands that four research areas have been chosen to run KTH RIs: ICT, life science, nanofabrication and materials. However, it remained unclear why and how these were selected”*. One observation from the evaluators is therefore that *“...the further development of KTH RIs could benefit from a clearly formulated alignment with the vision and strategy about the development of KTH as a technical university as a whole”*.

The experts also presented a number of recommendations where the most important might be to increase central funding for infrastructure, as the following statement captures: *“The panel unanimously agreed that KTH RIs are essential for maintaining long term excellence in research and innovation. ... The current funding level from central KTH does not reflect this status. It should therefore be increased substantially.”*

They recommended that KTH continues to develop initiatives with KTH RI and to formulate clearer rules for these, including rules for when central support is no longer valid and rules on what happens if a specific KTH RI does not follow internal guidelines, as well as more pronounced ideas and visions for internal infrastructure.

An area where the evaluators recommend further development in relation to KTH RI is communication. They stress the importance of clearer external communication, especially by utilising the worldwide web. Such communication efforts could focus on clearer common rules regarding fees for external users of KTH infrastructure, and by making the descriptions of what can be achieved when using the infrastructure even more convincing. In other words, they recommend that KTH uses the KTH RIs in a more ambitious branding strategy, especially internationally but also nationally and internally within KTH. The evaluators argue for a stronger central vision and steering of the KTH RIs but, at the same time, they stress that such ambitions need to be developed in close collaboration with KTH RI directors. They also stress the importance of centralised support really becoming a service that benefits all KTH infrastructures, and is not an administrative burden.

The evaluators noticed that much of the KTH RIs have advisory boards or steering groups, and so they recommend that KTH introduces international advisory boards for all. Another area where they made recommendations relates to the maintenance and operation of research infrastructure. They highlight that user fees and external funding sources will fluctuate, and that these differ across KTH RIs. They recommend that KTH centrally initiates an open discussion on how to cover the costs of the most essential personnel. Today, much of the maintenance and operation of infrastructure is work carried out by doctoral students and postdocs.

A related area in the reporting is how teaching and education might be supported by KTH RIs. The evaluators noted that some KTH RIs are used in teaching. This promotes quality and excellence in education and supports the financing of infrastructure. The evaluators, however, point out that this might lead to potential conflicts of interest, and they recommend that such issues are discussed between each KTH RI management team and the relevant school.

The evaluators also looked at each specific KTH RI management team and provided more general recommendations for each. They recommend increased collaboration across various infrastructures, both to reduce overlaps, to increase collaboration with complementary equipment and to share experiences in relation to administration, running and pricing of KTH RIs. They also recommend a further increased collaboration with external partners and, as mentioned, advisory boards for all KTH RIs. They mention a potential to align the KTH RIs so that they support KTH efforts to use large (international) research infrastructures such as MAX IV, when relevant.

The Electrum Laboratory and Albanova Nano Lab are highlighted as two role models for KTH RIs.

Sustainable development within the nine panels

The departments were asked to describe and assess their strategies to contribute to sustainability and the United Nations' Sustainable Development Goals (SDGs). They should reflect on expected results, how the results contribute to meeting the SDGs and the dissemination of the results. They were also requested to estimate how much of their research is related to sustainable development and if and how the department is working to increase the integration of sustainable development in the research base. The expert panels were then asked to assess each department in relation to sustainability and the SDGs.

All nine subject-based panels identified links between the research at departments within KTH and the SDGs, as

expressed by the United Nations. For many departments the experts have noted that their research is well-integrated with or linked to the SDGs. For one department the experts noted that “*All activities can be mapped onto SDGs*”, with similar statements provided about several others.

In many cases departments are especially active in relation to one or two of the SDGs, but in some cases broader scope and application was noticed; in one panel more than one department was reported to be strongly committed, and to have initiatives for all 17 goals.

In panel 1, the experts noticed that the Department of Sustainable Development, Environmental Science and Engineering (SEED), is viewed as providing potential for the whole of KTH to improve sustainability: “*... SEED clearly has the potential to be the glue around which a lot of sustainable development research at KTH can gel*”.

In a few of the nine subject-based panels, the experts noted an overlap between initiatives towards impact and towards sustainability, for individual departments. Comments on societal impact were also commonly provided, in places where the sustainable development work within individual departments is commented upon by the nine subject-based panels. The evaluators often noticed a potential for greater societal impact for KTH in relation to sustainable development.

The experts in panel 1 and panel 7 had broader discussions on sustainable development compared to other panels, and both noticed a widespread interest in sustainable development within their respective departments.

For some panels, the experts determined that relationships between departmental research and the SDGs is sufficient, or “as much as can be expected”. Such comments were in some cases given to those departments having a strong theoretical focus.

The overall impression provided by the experts is that research at KTH is often relevant or highly relevant for sustainable development, even though more internal collaboration is sometimes recommended and a strategic focus is sometimes lacking. KTH's strong collaboration with industry and other external actors is viewed as a potential for even stronger influence in the area of sustainable development.

Cross-panel on sustainable development

The overall impression from the cross-panel on sustainable development is that KTH is well-suited to taking a leading role in relation to sustainable development and that many good initiatives are already in place. The evaluators commend the KTH leadership for being well aware of the importance of and potential in work related to the UN goals on sustainable development, the SDGs, and they highlight an ambitious KTH policy on sustainable development and related measures for implementing this policy. This includes an observation that sustainable development is well-articulated in policy documents, the establishment of the Sustainability Office and the initiative with cross-disciplinary Research Platforms that incorporates sustainability in various aspects.

The evaluators do, however, also say that there appear to be gaps between the policies at university level (what they describe as “*high level policy*”) and the ongoing daily work within KTH (or in the words of the evaluators “*with actual 'lived experience' in research and associated professional activities*”). One example of such a gap is, according to the evaluators, that “*The incorporation of sustainability in the strategy of the Research Platforms does not appear to be widely recognised by the faculty, thus limiting the effectiveness of the Research Platforms in this regard.*”

In the discussion on potential development, they noticed that it would be desirable to incentivise researchers and teachers to work more with sustainable development, in order to better fulfil the great potential that KTH has in this area. In this matter they noticed that it is important to consider “*the strong tradition of 'bottom-up' faculty initiative and engagement*” in such efforts; in other words, to harmonise broader university-wide ambitions as formulated by the KTH leadership with the strong engagement that they observe among the faculty.

The evaluators noticed that KTH takes part in the Times Higher Education (THE) Impact Assessment and that KTH provided data for this evaluation based on Elsevier’s bibliometric assessment. Both these initiatives are based on each individual SDG. Such a focus might hinder broader ambitions to work across many SDGs and the evaluators highlight an initiative by one of the platforms, the project “AI and the Sustainable Development Goals”, as “*an excellent example of such integration with two important and visible outcomes*” and they mention that more examples of this kind exist.

They mention approximately 30 impact cases as illustrations of relevant projects and outcomes for sustainable development i.e. they identified many of the impact cases as great potential for KTH to communicate its work with sustainability and SDGs.

In addition to reflections on how KTH works with sustainable development, the evaluators make several recommendations. In relation to the observed need to incentivise the academic staff, they recommend that KTH includes sustainability in its promotion and in the hiring of new staff, not least the potential in renewal of research areas by hiring already established researchers with strong records in sustainability. They recommend that KTH gives the Sustainability Office a larger budget that could, for example, be used to establish awards for successful sustainability initiatives. The evaluators mention the potential of the Sustainability Office to be more active in relation to various initiatives with KTH. Such initiatives could perhaps be to work with internal sustainability goals within the university organisation and to activate staff and potentially students in campus development.

One recommendation is for the Vice President for Sustainable Development to establish a kind of advisory board for sustainability. Such a board could potentially attract internationally recognised researchers and it could help KTH develop new initiatives, boost the work with even broader cross-disciplinary ambitions and thereby potentially strengthen KTH’s potential to take leading roles in large programmes under Horizon Europe and tackle some of the missions and challenges related to the European Green Deal. This could enhance external funding opportunities. In relation to such funding, they also recommend that: “*KTH could, through its central administration and leadership, increase its efforts to assist faculty in acquiring external funding for research in sustainable development. This would include providing support to submit proposals for EU Horizon Europe programs, particularly those addressing the European Green Deal.*”

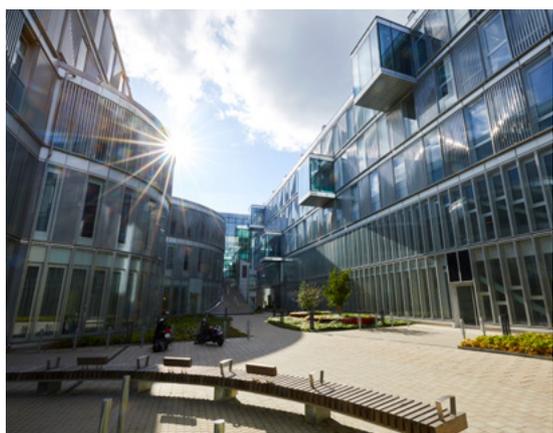
To further strengthen such ambitions, they recommend that: “*Faculty in the Schools and Departments could be mandated to work with the Sustainability Office to identify opportunities for cross-disciplinary collaborations that would support research related to sustainable development.*”

The evaluators recommend that KTH aligns its work within impact and diversity with the sustainability ambitions. As pointed out, they saw numerous examples of impact cases focusing on sustainability and they specifically noticed work within architecture that combined SDG number 5 and interesting and relevant diversity initiatives.

Missed opportunities were recognised in relation to “*... the general lack of integration across SDG:s. Here the Research Platforms may play a more active role and positive bottom-up initiatives can be highlighted and used as role models and for further discussions among faculty*”. It is also recommended that KTH investigates what the engaged academic staff perceive as the greatest barriers to working with sustainable development.

The evaluators conclude: *“With its policy on sustainable development and Sustainability Office, KTH has the essential elements in place to be an academic leader in sustainable development. With its strength as a leading technical university,*

KTH is well positioned to engage with industry and the local and regional community in promoting the implementation of research on sustainable development.”



KTH's five campus areas in Södertälje, Kista, Flemingsberg, Solna and central Stockholm.

Reflections on results

As detailed in the summary above, the evaluators have made a number of general observations and recommendations regarding future challenges for KTH, in order to sustain its excellence in research in relation to international peer universities. Most recommendations are, however, at departmental level, since it is the nine subject-based panels and their respective departments that are the focus of RAE 2021. In this chapter we (the authors of this summary report) will elaborate on some of these observations. This chapter therefore differs in relation to the others, as it is not a direct summary of the expert panel's recommendations. Instead, the purpose of this section of the report is to consider the observations in the KTH context and provide some reflections from a central university perspective.

RAE 2021 was focused on the research quality within KTH, and on how departments at KTH work with strategies for quality development. A general conclusion of RAE 2021 is that most feedback is provided at the department level; meaning that to a large extent there was a shortage of well-developed ideas on issues that were addressed to, and relevant for, the overall panel level. One reason for this may be that the panels are not perceived as “natural units” by evaluators and/or by the departments included in some panels.

The experts have, however, given KTH numerous relevant insights and pointed to some general challenges for the organisation as a whole, such as the distribution of direct governmental funding for research at KTH, the high dependence on external resources, the recruitment processes, and administrative matters within KTH. However, these topics were not the focus of this RAE, and therefore the experts were not presented information from, or interviews with, actors at KTH that have responsibility for e.g. internal funding, central rules, or processes for recruitment or administration.

Internal funding within KTH

In various ways, all nine subject-based panels commented on the distribution of research funding within KTH. One problematic aspect highlighted was the unclear principles (according to the interviewed faculty) regarding the internal distribution of resources. Principally KTH, just as all other universities in Sweden, receives its basic internal funding from the government. These resources come in two different categories: one for research, including doctoral student training and infrastructure, and one for education. The funds that KTH receives for research are, to a very high degree, distributed to schools and departments. Only a minor share is kept at central level, for central initiatives.

The resources that go to departments are mainly based on historical aspects, such as original funding for faculty positions and participation in SRAs (Strategic Research Areas, which is a governmental initiative). Part of the internal resources allocated to departments are also based on quality indicators. Here, it is important to bear in mind that

the expert panels were not given detailed information about the internal distribution model. However, it is clear from the evaluations that KTH needs to address the transparency of the process of allocation of direct government funding. It is also clear that the experts provided a range of ideas on how to distribute resources differently, and that many choices exist for the university in this matter, which should be coupled to the outcomes that both the departments and KTH seek. A process to investigate and review this topic has already been initiated (see more in chapter Next Steps, starting on page 33), and RAE 2021 has pinpointed the importance of this work, both in terms of a discussion on what principles to follow and in terms of making these principles transparent.

Another general aspect identified by all nine subject-based panels was that they each gave examples of departments that they recommend should be allocated a higher share of internal research funding. This may seem logical when looking at each individual department, however, at the aggregated level KTH would need to reallocate funding from either another department, central or school level initiative, or from administration (e.g. via overhead costs), unless KTH is awarded an increase in direct funding from the government.

Here, it is of interest to look more closely into the arguments the evaluators have offered, that support increases in central research funding to individual departments. The most common argument was that research in the particular department is strong, and that to be able to continue to develop their particular subject area or theme, more resources will be needed. One interpretation of this situation is that it is a risk that relatively few internal resources lead to relatively unattractive positions for international researchers i.e. if KTH cannot offer a reasonable cover for internal salaries or additional funding for doctoral students, post-docs or research in general, it will be much harder for KTH to remain internationally attractive. A related argument provided by one panel was about a specific department; that it has clear potential for further development, if KTH is able to provide dedicated funding for positions that can open new areas for research in that field. To conclude, the question of how to tackle these matters ought to be discussed at various levels within KTH.

Only a few of the expert panels recognised the problem of resource reallocation within KTH; pointing to the university-wide challenge of increasing internal funding for individual departments.

High dependence on external resources

KTH is a research-intensive university, with approximately 24% of the annual budget directed to education and 76% to research in 2020. About 61% of research funding each year is received in competition. This was also the case in 2012. The large difference compared to 2012 is the increased demand of co-funding from many of the external funding providers, which results in a lesser amount of internal funding for strategic priorities.

The issue of high dependence on external resources was mentioned in various forms in all panels. The positive side, identified by most panels, is that competent, qualified and competitive researchers at KTH are successful in attracting research funding both nationally and within the EU, and that many research groups get extensive as well as prestigious funding in this way. All panels were made aware that the Swedish research system, to a comparatively high degree, builds on external funding. In general terms, Sweden has a high level of research funding in relation to GDP, including relatively high governmental research expenditure. Experts were also presented with figures showing that in recent decades the Swedish government has increased funding for research agencies (such as the Swedish Research Council (VR), Vinnova, and Formas), to a higher percentage than those increases in research funds allocated to universities. This implies that Swedish universities, having competitive and qualified researchers, will over time attract an increasing share of external resources – and furthermore, that the balance between internal and external research funding sources will decrease as researchers become more successful in attracting external resources. Only a few of the panels observed this important relationship between internal and external funding.

On the other hand, all panels highlighted what, in this kind of system, can be understood as a negative effect of the successful allocation of external resources. Many of the panels identified highly competitive research groups within KTH and noticed that they had been able to expand their activities, and for example open new areas of research. At the same time our international peers have pointed to the lack of internal resources for what they describe as “blue-sky” research. The previously discussed high level of dependence on external resources is seen as a threat to the ability of academic staff at KTH to initiate their own original research topics, relevant in the long-term. Many of the panels also stated that individual departments, as well as

the central organisation, should look more carefully into this balance.

The positive side of being excellent in attracting external funding should, according to the evaluators, be understood in relation to the risks associated with focusing on issues more relevant in the short-term, and on topics that are of a high priority to industry or other external partners. A logical concern about those researchers and departments that are especially successful in attracting external funds is that, in today’s Swedish academic system, such researchers and departments are at risk of losing their academic independence, or at least risk losing the initiative to choose research topics.

Another, related interpretation of many of the comments from the evaluators is that the high dependence on external resources also reduces the potential for internal collaboration. In most panels, experts identified the potential for increased internal collaboration, sometimes within the individual department, sometimes within the panel and sometimes within KTH at large. In some of the panels, the evaluators noticed that researchers at KTH are under great pressure to increase external funding, and noticed a lack of time to work more on collaborations and strategies for the long-term development of research. One interpretation is that such observations, at least partly, can be explained by the high dependence on external resources, which are often short-term and, as noted above, more or less prioritised by other actors. High dependence on external funding is a topic that needs further discussion, and that actors at many levels across KTH must consider in greater detail.

Academic leadership

As noted, the evaluators are impressed by the quality of research at KTH. Many of the panels link this successful outcome to a vibrant and “bottom-up” driven scientific process with high engagement from, and capacity among, individual researchers. The local leadership within many departments is also praised.

On the other hand, in most panels the evaluators notice a variety of shortcomings in relation to strategic plans or roadmaps for implementing such plans, both for the panel as a whole and for individual departments. They also point to overlaps within panels or between departments from differing panels, as well as a fragmentation of competences, and too small research groups in some areas (low critical mass). There are examples of comments where the experts identify a lack of strategy for the recruitment of high-profile researchers, or recruitment within potentially highly important areas. Other partly related topics where the evaluators find that some departments fall short, include

professional support in writing (larger) applications, renewal of research, renewal of research infrastructure, gaps between central initiatives and the daily work in departments for strategies to improve impact and outreach.

This might be seen as paradoxical. On the one hand, the evaluators state that the quality of research, the connectedness within the scientific community, the societal impact of the research and the leadership at departmental level at KTH is good and even excellent in many areas. On the other hand, they identify shortcomings in strategic thinking or a lack of roadmaps to fulfil strategies where they exist, at all levels within KTH, which can lead to missed opportunities according to the evaluators.

Such comments can be interpreted as critical for various aspects of the strategic leadership at KTH. One reflection to such an interpretation is that comments on potential lack of strategic planning at panel level isn't surprising. The grouping of departments into panels in RAE 2021 is not an organisational structure within KTH, it is a way to group departments for this evaluation, based on their scientific subjects. In other words, there exist no "panel leadership" within KTH and there is therefore no actor that is formally responsible for "the strategic planning at panel level". Another reflection is that the evaluators did not have discussions with, or written material from, the central leadership at KTH or the leadership at school level since such issues were not in focus for this RAE.

The self-evaluations included aspects on leadership and strategic planning at departmental level and here the evaluators were largely positive or directly impressed. On the other hand, the experts had many comments that can be interpreted as critique towards academic leadership in general within KTH, especially related to strategies and roadmaps and also at the department level.

However, based on the observations it is obvious that KTH needs to reflect carefully on these matters. The feedback from the experts has focused on potential improvements at KTH. Academic leadership for strategies and roadmaps is one such area including the challenge of combining successful "bottom-up" based scientific engagement, with more long-term, "top-down" initiatives, especially related to internal funding, multi-disciplinary collaboration, scientific renewal, recruitment, and research infrastructure.

The recruitment process

Another area for improvement highlighted by almost all of the panels is a critique of the recruitment processes within KTH, which is said to be (far too) slow. A number of the panels would also like to see a stronger influence from the

academic staff over the recruitment process within individual departments.

As mentioned, evaluators were not provided with information on national conditions for Swedish university recruitment or for the KTH practice, nor did they interview any representative with responsibility for KTH recruitment processes. However, it is clear that the international experts have concerns for the departments that they evaluated, in relation to the potential for these departments to attract internationally profiled researchers, due to what they describe as "*too slow and cumbersome*" a process for recruitment. Clearly, KTH will need to continue to work on improving these processes.

Administrative issues

A parallel to the observations on recruitment are the recurrent comments on the administrative tasks that the experts noted among the academic staff at KTH. As with recruitment, our international peers were not provided with any information on administrative tasks within the Swedish university system, including KTH, nor did they have any interviews with representatives for the administration, since that was not the focus of the RAE 2021. Much can be said on the increased number of issues and aspects that the Swedish government imposes on universities, but the RAE 2021 is not the place for that.

No matter the reason for the development of the administrative costs, routines and tasks within KTH, it is obvious that the experts in RAE 2021 think KTH could do better in this area. In addition to comments on high overhead costs, another common observation was that the KTH administration is often interpreted as not supporting the researchers or, stated in other terms, the administration focuses on topics that researchers at KTH do not see the point of. One interpretation is therefore that the evaluators recommend that KTH looks at whether the administration can be reorganised. One way to interpret their comments is that they are recommending a less costly and more decentralised administration with an improved focus on everyday issues at the departmental level.

Untapped potential

Closely linked to these observations are other comments from the evaluators, regarding various forms of potential that KTH has not yet made full use of. As pointed out elsewhere in this report, our peers are impressed by the research at KTH, by the strong links to industry and the public sector, and by the high engagement in impact and societal development from the academic staff. Many of the panels point out the potential for KTH to make greater

contributions to sustainable development goals and the wider implementation of research results. The impressive results of many individual research groups are, broadly speaking, observed in parallel to a lack of long-term strategies for e.g. increased impact. Another observation from some of the panels, including the cross-panels on impact and sustainable development, is the perceived gap between central initiatives and daily practices within departments that support sustainability.

In some panels, evaluators identified a potential for more multi-, cross- or interdisciplinary research. This can be interpreted as a potential for KTH to be more successful in larger initiatives focusing on societal challenges, as the experts have pointed out that KTH has a very good basis for this. One way to interpret these observations from the evaluators is, however, that the balance between internal university funding and external resources does not speak in favour of fulfilling such potential at present.

Another reflection on the observations made of many strong and successful KTH research groups, in combination with the high dependence on external resources, is that there is a need for developing broader themes within KTH where individual research groups, based on their own priorities, can identify areas where they can contribute to common goals, without being seen as individual “musicians”, ordered to play exactly as the conductor decides. Time and discussions are most probably needed, in order to identify and articulate such broader themes. This might be one way to address some of the expert comments regarding the lack of long-term strategies and roadmaps.

Gender and diversity

It is no surprise that many of the panels highlight gender issues. Often they point to a lack of female faculty members, but in some of the panels’ comments are broader and point to a need for individual departments, as well as KTH at large, to look more closely into these issues. At the same time, the evaluators also noticed that some departments either have a good gender balance or that they have ongoing research that is highly relevant in relation to gender aspects and issues. This could be interpreted as a potential opportunity for departments within KTH to learn from each other.

Infrastructure

Research at KTH is often highly dependent on research infrastructure. This was observed in many panels. As noted above, the general overview is that the evaluators were impressed by the research infrastructure at KTH. At the same time, it is clear from the reporting that many of the evaluators do not think that dedicated governmental or

central KTH funding for research infrastructure is sufficient for a competitive technical university, in the long term. One interpretation is also that they were sometimes surprised by the lack of dedicated funds for technicians, and how that could affect the continuing operation and service of research infrastructure. The initiative to allocate a portion of government sourced research grant funding to larger research infrastructures at KTH is praised by the evaluators in the infrastructure cross-panel, even though they stated that the level of that internal funding is too limited. In many of the nine subject-based panels the experts recommended more internal funding. One can interpret these comments as follows: on the one hand, KTH needs to join with other Swedish universities and partners and argue for more governmental funding, but on the other hand, must also increase collaborations with other universities and partners, in improving the utilisation and funding of KTH research infrastructure. Given the many comments received regarding the lack of funding for technicians and the long-term operation and service of research infrastructure, this topic is at least as important as the question of long-term finance for the maintenance and renewal of research infrastructure. In general, these topics are of great importance to a technical university such as KTH.

Next steps

The results from the RAE 2021 are of great value for both the quality assurance work at KTH and for its future competitiveness. These findings provide KTH with valuable insights into how the university can further develop its research, in both the short and the long-term. How this will be addressed in the future can be clearly seen in KTH's operational plan for 2022. For example, each respective Head of School has been tasked, in dialogue with the Heads of Department, to analyse the RAE reports, identify possible development areas and produce an action plan for how the recommendations are to be acted upon. This assignment includes identifying measures for both department and schoolwide collaborations that can contribute to increasing the quality of KTH's research. The assignment will be implemented within the quality system, especially via on-going monitoring of research in 2022 and 2023, headed by the Dean of Faculty.

Numerous assignments concern specific issues, such as publication strategies and scientific impact. Ranking is important for the future competitiveness of KTH not only when it comes to recruiting researchers and students, but also in the competition for external funding for research. For some time, KTH has been working to stimulate stronger and conscious publication strategies, for example via dialogues chaired by the Deputy President and as a theme in RAE 2021. KTH is going to engage in strategic development work to further build on the lessons from the above in 2022, where researchers will focus on both strategies for the choice of publication channel, and systematic efforts to communicate about current research and publications. This is also linked to the systematic work for simplifying bibliographical analysis both for individual researchers, departments and larger research collaborations in the Annual Bibliometric Monitoring at KTH.

Making research more visible will also help KTH to climb in the important ranking lists. Therefore, in the operational plan for 2022, the Deputy President has been given the task of engaging in development work together with the Heads of School to strengthen the scientific reach of our research. This work aims to strengthen strategic publication via publication and communication strategies, to increase the visibility and reach of KTH research, in order to lead KTH to a higher position among international rankings. The Heads of School have also been tasked with developing an action plan, with measures for each respective school, in dialogue with the Heads of Department. The above also includes identifying environments where citation rates are low over time and to identify activities with the environments concerned to incorporate in the action plan for the school.

Relevant and appropriate research infrastructure is also of fundamental importance for outstanding research, and KTH accordingly analyses the need for strategic research infra-

structure on an ongoing basis and seeks to ensure that investments are utilised in the most effective way and as broadly as possible. Based on the recommendations from the cross-panel on infrastructure, the Deputy President has been tasked with analysing recommendations and viewpoints and to produce a long-term road map for KTH's research infrastructure.

The Vice President for Sustainable Development has been tasked with analysing the recommendations and viewpoints from the cross-panel on sustainable development, and to propose possible actions. In addition, the Vice President for Sustainable Development will be allocated funds in 2022 for investments within environment and sustainable development across departments. These investments are to be oriented towards improvement measures within sustainable development that have been identified in RAE 2021.

Impact was yet another theme area for RAE 2021, where the experts analysed how the departments contribute to impact and KTH support in this area. In 2021, the impact-leader initiative was also evaluated. Based on the recommendations from the cross-panel on impact, and the evaluation of the impact leader initiative, the Deputy President has been tasked with analysing recommendations and viewpoints and to produce a plan for possible measures to take.

KTH is systematically working to establish and develop strategic partnerships with parties outside higher education that are key for KTH. In 2021, KTH's strategic partnerships were reviewed. KTH also participated in an international bench learning programme (accelerator) that focused on strategic partnerships. To a certain extent, this has been included in the cross-panel on impact in RAE 2021. Headed by the Deputy President, the lessons learnt will be applied in work to further develop our strategic partnerships.

A number of important changes and development initiatives that were previously formulated into the KTH operational plan for 2021, were also identified as prioritised areas by the experts. Faculty and University Administration at KTH have made significant progress in many of these assignments. Having said that, several of these assignments are of such a character that means they are not simple enough to complete over a single year and should accordingly be viewed as long-term development assignments that may span over several years.

The faculty recruitment process is a key to KTH's competitiveness. In the operational plan for 2022, the Dean of Faculty, who is also Chair of the Appointment Board, is tasked, in consultation with School Heads of Faculty Recruitment and Development, to ensure appropriate transparency around and the effectiveness of, the appointments process for

faculty positions. Specific focus should be given to understanding how an appropriate and effective process depends on the cooperation of all parties involved. The need for this was clarified in association with the RAE review.

As part of the development-oriented analysis of KTH support services in 2021, the University Director has engaged in dialogue with the Heads of School and Administrative Managers, with the Heads of Divisions within the University Administration and trade unions, to discuss the development of effective university administration. RAE 2021 highlights the need to develop adequate university administrative support for research at KTH. Here, an evaluation of the university administration can contribute to showing and clarifying what administrative support is available and needed at different levels at KTH and in communicating knowledge among the research staff concerning how KTH is governed.

In connection with the evaluation of university administration, a review of the KTH resource allocation model, i.e. the internal funding model, was previously initiated as an assignment in the operational plan for 2021, before RAE 2021 was completed. This work is being synchronised with the KTH planning and monitoring process, for example in the development of the KTH operational plan and the operational plan for university administration. The work to ensure professional, relevant and consistent university administration will continue in 2022 (and possibly also 2023) with the focus on an increased coordination and development of processes within the various different areas of university administration.

In parallel with acting upon the expert panel recommendations, KTH will also evaluate the RAE process itself. In so doing, the university can incorporate the experiences from this evaluation, and recommend changes to the KTH quality assurance system in time for the next external review.

Invited experts

Panel 1 Architecture and built environment

Prof Murray Fraser, CHAIR
The Bartlett School of Architecture, UCL, UK

Prof Eeva-Liisa Pelkonen
Yale School of Architecture, US

Prof Graham Haughton
The University of Manchester, UK

Prof Alfred Nordmann
Technische Universität Darmstadt, DE

Prof Allison Kealy **RMIT University, AU**

Prof Jarek Kurnitski
Tallinn University of Technology, EE

Senior consultant Dag Björklund
Björklund Fastighetskompetens AB, SE

Prof Eleni Chatz **ETH Zurich, CH**

Prof Vanesa Castan Broto
The University of Sheffield, UK

Prof Christopher Kennedy **University of Victoria, CA**

Prof Stefan Anderberg **Linköping University, SE**

Panel 2 Biotechnology

Prof Dario Neri, CHAIR **ETH Zurich, CH**

Prof Preethi Gunaratne **University of Houston, US**

Prof Markku Kulomaa **Tampere University, FI**

Prof Nicole Borth **University of Life Sciences, AT**

Prof Janna Saarela **University of Oslo, NO**

Prof Roland Wohlgemuth
Technical University of Lodz, PL

Prof Jennifer van Eyk
Cedars-Sinai Medical Center, US

Dr Alvis Brazma
The European Bioinformatics Institute, UK

Panel 3 Chemistry and Materials Science

Prof Heikki Tenhu, CHAIR **University of Helsinki, FI**

Prof Rasmita Raval **University of Liverpool, UK**

Prof Annick Hubin **Vrije Universiteit Brussel, BE**

Prof Marcel Somers
Technical University of Denmark, DK

Head of Project Management Office,
Rose-Marie Fälling Yttergren **Höganäs AB, SE**

Prof Andreas Dreuw **University of Heidelberg, DE**

Prof Philippe Poulin
Centre de Recherche Paul Pascal - CNRS, University of Bordeaux, FR

Prof Anne-Marie Hermansson
Chalmers University of Technology, SE

Panel 4 Computer Science

Prof Virgil Gligor, CHAIR
Carnegie Mellon University, US

Prof Raouf Boutaba **University of Waterloo, CA**

Prof Gene Tsudik **University of California, US**

Prof Ellen Zegura **Georgia Tech, US**

Prof David Basin
Swiss Federal Institute of Technology (EPFL), CH

Prof Antony Ephremides **University of Maryland, US**

Prof Anne-Marie Kermarrec
Swiss Federal Institute of Technology (EPFL), CH

Prof Lixia Zhang **UCLA, US**

Prof Jodi Forlizzi **Carnegie Mellon University, US**

Prof Steve Benford
The University of Nottingham, UK

Prof Ahmad-Reza Sadeghi
Technische Universität Darmstadt, DE

Panel 5

Intelligent Systems and Biomedical Engineering

Prof Bart De Moor, CHAIR **KU Leuven, BE**

Prof Aylin Yener **Ohio State University, US**

Prof Lina Sarro **Technische Universiteit Delft, NL**

Prof Richard Goossens
Technische Universiteit Delft, NL

Prof John Clarkson **University of Cambridge, UK**

Prof Jos Vander Sloten **KU Leuven, BE**

Prof Carlos Canudas de Wit **GIPSA-lab, FR**

Prof Tanja Schultz **Universität Bremen, DE**

Prof Athina Petropulu
Rutgers, The State University of New Jersey, US

Panel 6 Energy and Electrical Engineering

Prof Luisa F. Cabeza, CHAIR **University of Lleida, ES**

Prof Tomás Gomez **Comillas Pontifical University, ES**

Prof Tulika Mitra
National University of Singapore, SG

Prof Farhad Rachidi
Swiss Federal Institute of Technology (EPFL), CH

Prof Emeritus Kevin Bennett
University of Cape Town, ZA

Prof Henrik Bindslev
University of Southern Denmark, DK

Prof Elena A. Lomonova
Eindhoven University of Technology, NL

Prof Lis Nanver **University of Twente, NL**

Panel 7 Mechanical and Industrial Engineering

Prof Emeritus Eero Eloranta, CHAIR
Aalto University, FI

Prof Dinesh Verma
Stevens Institute of Technology, US

Prof Anja Maier **Technical University of Denmark, DK**

Dr Christoph Hanisch **Festo AG & Co, DE**

Prof Doriana d'Addona
University of Naples Federico II, IT

Prof Bart Rienties **The Open University, UK**

Prof Jan-Ola Strandhagen **NTNU, NO**

Prof Pascal Le Masson **MINES ParisTech, FR**

Panel 8 Mathematics and Engineering Mechanics

Prof Nilima Nigam, CHAIR
Simon Fraser University, CA

Prof Jorge Ambrosio, CHAIR
Technical University of Lisbon, PT

Prof Antti Kupiainen **University of Helsinki, FI**

Prof Gert-Martin Greuel
University of Kaiserslautern, DE

Prof Marta Sanz-Solé **University of Barcelona, ES**

Prof Jonathan Cooper **Bristol University, UK**

Prof Veronique Doquet
L'École polytechnique - Université Paris-Saclay, FR

Prof Shelley Anna **Carnegie Mellon University, US**

Head of Data Science, Salla Franzén **SEB, SE**

Director External Research, Stefan Christiernin
Volvo Cars, SE

Panel 9 Physics and Applied Physics

Prof Wolfgang Eberhardt, CHAIR **DESY - CFEL, DE**

Prof Olga Botner **Uppsala university, SE**

Prof Yassin Hassan **Texas A&M University, US**

Prof Emeritus Horst Vogel
Swiss Federal Institute of Technology (EPFL), CH

CEO David Sonnek **Industrifonden, SE**

Prof Eleni Diamanti **Sorbonne Université, FR**

Prof Martti Kauranen **Tampere University, FI**

Prof Stephanie Reimann **Lund University, SE**

Cross-Panel Impact

Prof Tim Bedford, CHAIR
University of Strathclyde, UK

Director Jakob Fritz Hansen
Technical University of Denmark, DK

Prof Tamer Basar **University of Illinois, US**

Cross-Panel Sustainable Developmen

Prof Janet Hering, CHAIR **ETH Zurich, CH**

Dr Wolfgang Hribernik **AIT, AT**

Prof Magnus Breitholtz **Stockholm University, SE**

Cross-Panel Infrastructure

Prof Max Lemme, CHAIR **Aachen University, DE**

Director Christine Nellemann
Technical University of Denmark, DK

Prof Viktor Öwall **Lund University, SE**

