Expert report, panel 8

KTH's Research Assessment Exercise (RAE) 2021

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Introduction

This expert panel report is part of the Research Assessment Exercise (RAE) 2021 at KTH Royal Institute of Technology. The report is based on the self-evaluation on panel 8 and aims to provide recommendations and feedback to the involved departments and KTH.

Expert panellists:

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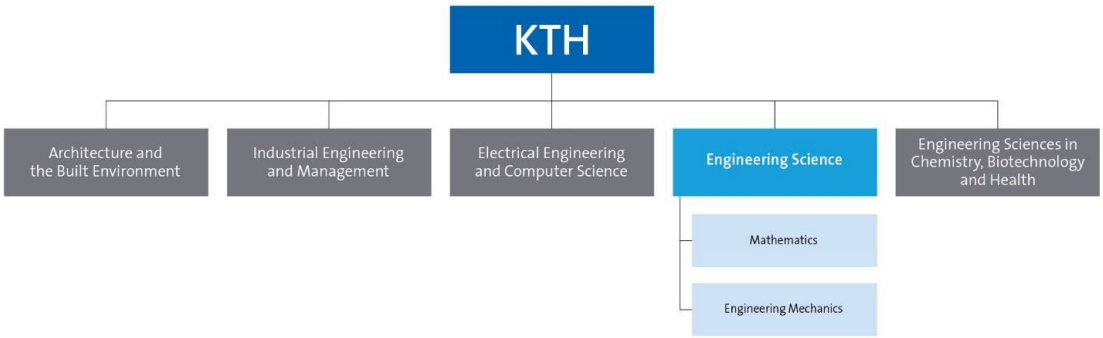
- Prof Shelley Anna, Carnegie Mellon University, US
- Dr. Stefan Christiernin, Director External Research, Volvo Cars, SE
- Prof Jonathan Cooper, Bristol University, UK
- Prof Veronique Doquet, L'École polytechnique, Université Paris-Saclay, FR
- Dr. Salla Franzén, Head of data science, SEB, SE
- Prof Gert-Martin Greuel, University of Kaiserslautern, DE
- Prof Antti Kupiainen, University of Helsinki, FI
- Prof Nilima Nigam, co-chair, Simon Fraser University, CA
- Prof Marta Sanz-Solé, University of Barcelona, ES

Panel 8

Coordinator: Prof. Anna-Karin Tornberg, KTH Royal Institute of Technology.
Vice-coordinator: Prof. Sebastian Stichel, KTH Royal Institute of Technology



Part A: Summary of the whole panel

1. Strengths, weaknesses, and recommendations

Common to the departments within the research area covered by the panel

Common strengths:

- Some divisions and staff are recognised as world-leading in their research areas.
- Good international visibility and connections/collaborations.
- Excellent external funding with diversified sources.
- Good collegial environment and interaction between divisions and with other groups.
- Excellent research environment: seminars/workshops/showcases. Good research infrastructures with showcases such as institutes/research centres.

Common weaknesses:

- There is heterogeneity in the sizes of divisions leading to some issues on the critical mass of some and on their ability to develop long-term strategies including hiring and renewal.
- Mentoring new staff is informal. Although it seems to be working well there is little or no room for unforeseen problems.
- No clear task loading strategy, eventually leading to some tension between administrative, teaching and research load balance.
- Very slow recruitment processes in comparison with international peer departments, leading to decreasing opportunities for the hiring of top good candidates and relying on external committees even for the long-list stage.
- Weakness on the recruitment of full professors.
- Faculty does not seem to use sabbatical leaves as a form to develop careers and strengthen international relations.
- Internal funding model is posing challenges: faculty must prioritize externally-funded work, and graduate programs are critically dependent on external funding. This leads to uncertainty.

Common recommendations:

- Continue high-level research across Mathematics.
- Help new divisions/Thematic Areas in Engineering Mechanics reach their potential by developing a strategy/vision, supported with new hires or renewal of faculty, eventually letting less vibrant topics be replaced by emerging ones.
- Implementation of Department-wide accounting of faculty workload to take into account teaching, administrative support, research and extension activities.

- Encourage the use of the sabbatical leave programme to help strengthen international and industrial relations.
- Recruit at all levels: senior faculty to start new research directions, junior faculty for growth.
- Speed up recruitment processes.
- Find more creative ways to obtain administrative support by complementing central KTH support with internal matching funds, eventually by creating a small internal overhead on funding.

2. Feedback on the formulated visions and strategies

That can lead to increased quality of research at KTH and increased impact

Some reviewers felt Divisions could investigate the development/use of Key Performance Indices, which may assist in bargaining for new hires and also for mentoring new faculty. We recognize such measures are not common in Mathematics, whereas they are in some Engineering disciplines.

The potential of the candidates to apply for ERC grants can have a strong weight on the hiring of young faculty. As such young faculty have not only the potential to shape the future of the research of KTH for some decades but also to state in which scientific areas to invest today this ERC grant potential is a good measure of expectation.

3. Ideas and recommendations for essential steps

To be taken to renew research areas

Administrative support for common tasks, such as assistance on proposal writing for major grants or financial reporting on funding, among others, to allow researchers to use their efforts on the technical matters rather than on the administrative issues.

Strengthen the numbers of faculty, i.e., permanent research and teaching staff, rather than ‘substituting’ them by temporary research staff, i.e., post-doc, generally based on the funding secured. The identification of the correct balance, which may be different for different Departments, is encouraged.

Define and maintain a strategy to identify new research areas in which to invest. This strategy, balanced with the renewal of faculty, either by hiring for particular profiles or replacing retiring faculty by new ones with a shift in focus, ensures maintaining the Departments with active research in the most vibrant (and eventually funded) scientific areas.

4. Potential links and synergies

Between the departments within the research area *covered by the panel and other parts of KTH*

The structure and cultures in the Departments, and even inside each Department, seems to be quite heterogeneous. However, there are common research topics handled by the researchers, and faculty in both Departments (such as Optimization, Artificial Intelligence, Data Science, Numerical Methods, etc.) that can lead to synergies fostered either by direct contacts or via the research centres in which both Departments are involved. A difficulty to overcome is the completely different culture of the Departments in defining and crediting the quality of the research in terms of Key Performing Indices.

The teaching activities, understood as an extension of the research to renew and update teaching, may also benefit from synergies of the different Departments, in particular when dealing with more multidisciplinary topics. Via teaching sharing it is possible to better explore synergies, even in research.

5. Recommendations for strengthening the departments and their future potential

We list common recommendations here. Specific recommendations for each Department can be found in Part B of this report.

- Divisions seemed to be organized by teaching/historical reasons/application area, and there is considerable variation in size. The Departments are encouraged to reflect on the academic utility of these Divisions, ensuring potential synergies are not being missed, and update organizational structure as needed.

- The recruitment of faculty at all levels remains crucial. The Departments are strongly encouraged to recruit beyond the bare minimum numbers required to maintain teaching capacity, as well as to strategically develop research areas of importance.

- The establishment of Departmental-level support for career development/mentoring of students is encouraged. Such support could also include making existing PhD-student initiatives systematic; provide support for the teaching assistants to make notes, pass on and share, support for the students and postdocs to document and pass on instructions and routines for research equipment.

- Reports of eventual abuses at the Math and Engineering Mechanics departments are very low, or non-existent, when compared to the percentage of cases reported in other similar Universities in Sweden. Thus, a continuous monitoring of eventual unreported cases is advised, as is the establishment of a Departmental Ombudsman.

- The use of the new sabbatical programme should be encouraged.

6. Recommendations applicable to the whole of KTH

The units themselves identify, and we concur, that recruitment and retention of faculty appears to be a dominant concern. We recommend as a matter of urgency that these processes be streamlined. Recruitment processes are too slow to allow KTH to continue to compete for top-class international talent. The request that new faculty is able to teach in Swedish is a very strong limitation when trying to hire some of the most competitive candidates. We recommend KTH undertake a review of its recruitment and retention processes and examine best practices at universities of a similar stature internationally.

Furthermore, the current internal funding model leads to uncertainty in working conditions (in terms of teaching loads/time for research), as well as important graduate programs. This is not a sustainable model. Instead, the creation of a model in which the load sharing between research, teaching and administrative activities is defined (eventually limited by thresholds) is recommended. We noted an extreme dependence (relative to international peer departments) of the doctoral programs/PDFs on external funding, and the consequent risk to the continuity of programs particularly in basic or 'blue-sky' research. KTH senior leadership needs to urgently examine the research and training impact of these policies. There is a true tension between the availability of internal funding and the need to secure external funding, which is then reflected in tensions between time allocated to externally-sponsored research compared to stably meeting teaching and administrative needs of the department.

Regulations around teaching for Assistant Professors biases hiring in the direction of senior hires, which in turn are more expensive. Given these factors, this appears a problematic funding model.

Since both departments are heavily dependent on external funding, the availability of administrative support for applying and managing research projects is advised. This support not only allows managing more efficient tasks common to all projects and transversal to the Departments (such as financial reporting or contract handling) but also provides the faculty (and researchers) with background support for writing of larger funding proposals.

Part B: Report for each department

Department of Mathematics

Major findings

1. Strengths and weaknesses of the department
Concerned and recommendations for improvement

Strengths: The Department of Mathematics continues to be a world-class research department.

- Some divisions and staff are recognised as world-leading
- Good international visibility and connections / collaborations
- High quality publications in top-tier journals
- Excellent external funding
- Good collegial environment and interaction between divisions
- High-quality training programs, including the co-supervision of PhD students across the disciplines
- Good criteria and guidance for career path and promotion process for new academics
- Good research environment - seminars / workshops / showcases. Good research infrastructures with showcases such as - institutes / research centres - LINE FLOW / IML (Mittag-Leffler)
- Some interactions with other Depts (electrical, CS) across KTH
- New degree programme in Engineering Mathematics is already successful

Weaknesses:

- The Divisions appear organized primarily around teaching or historical reasons. There is heterogeneity in the sizes of divisions. The grant sources and funding performance is varied. Are smaller divisions at a disadvantage when it comes to hiring?
- Mentoring of new staff is informal but seems to be working well
- Large teaching load - impinges upon research capabilities
    - High turnover of staff
- Very slow recruitment processes in comparison with international peer departments
    - Missing opportunities for the hiring of top good candidates (they go elsewhere)
    - Relying on external committees even for the long-list stage
    - Smaller divisions were recommended to add faculty in the previous RAE, and to develop a cohesive strategy. The ongoing recruitment/retention problems have prevented this. Few applications to ERC.

- Dependent on a small number of external funding sources (National Funding and Foundations) and an effectively decreasing internal funding
    - Influences the topics that can be worked upon, with the potential to bias towards short-term projects
    - Influences hiring of faculty: some uncertainty about work conditions
- No recruitment of full professors
- Not many staff going on sabbatical
- Application-oriented work and industrial engagement is 'bottom-up', with the Department perhaps not adequately showcasing its successes in this regard. Are these endeavours valued at the strategic level?
- Industrial partners cannot readily identify research points-of-contact.

2. Relevant and forward-looking objectives

Are the goals relevant and forward-oriented?

The department identified amongst its main goals for development over the next 5–10 years: to broaden the existing excellent research environment to a wider range of mathematical sciences and to establish an internationally leading role in an increasing number of research areas, (e.g., by hiring excellent faculty, in particular to aim for gender equality, diversity and equal treatment) and to create a working environment based on open-mindedness, curiosity and respect. Specific goals are to accelerate development in the recently established division of mathematics for Data and AI and to use the potential of research in this area for applications outside mathematics as well as to increase the collaboration within the department

The goals are relevant and forward-oriented but also challenging.

3. International community engagement

The department is very strongly engaged internationally. New faculty is recruited internationally and there is consequently a large international component in the faculty. The department has 30 postdocs, most of them from abroad. A large majority of research collaboration is international, as are co-publications. Grants from the Wallenberg foundation has been used for long term visiting positions for foreign professors (10 professors since 2014). The department is a partner in an EU-cost action network and EU-MORNET. The department is involved in several interdisciplinary centres with large international components. Through the Mittag-Leffler institute the faculty is involved in organising international thematic programs and members of the faculty take actively part in organising programs in several international mathematics research institutes such as Banff International Research Station, Erwin Schrödinger institute, Institut Henri Poincare, Mathematisches Institut Oberwolfach, Fields, Mathematical Sciences Research Institute at Berkeley and ICERM.

4. Future potential of the department

For a positive development towards fulfilling their goals, operating on the front line of international research, and exerting a beneficial impact on society

The department identifies, and the reviewers agree, there is some potential to increase internal collaboration within the Department and across KTH. These collaborations can then position groups to promote research activities with both external and internal partners. This can also mitigate the potential issues of the varying size and relatively large number of divisions hindering multidisciplinary collaborations. We encourage leveraging the KTH ecosystem of centres, labs and other collaborative initiatives.

The application for present and future large calls/initiatives both domestically and from the EU programs typically require large research teams or consortia. We suggest the department could encourage internal, (potentially cross-divisional) teams to apply for these grants. It would be helpful to create administrative support for the application process.

In order to continue recruiting excellent candidates with a significant proportion of women, the unit needs to continue to improve on internal aspects of the recruitment process to make it faster and more continuous. The teaching load in the Department is very high, and the slowness of the recruitment process creates an even higher workload for existing faculty.

A mentor system could be developed for tenure track faculty, with input from those who have recently been promoted taken into account. The promotion process at KTH could be made less cumbersome.

The faculty should be supported to apply to the new centrally financed program for sabbatical research visits.

The Division of Mathematics for AI and Data science is new within the department. The department needs to work out a development strategy for this field, in order to also optimally leverage the existing and future expertise within the department. This includes keeping the possibility open of recruiting a well-established professor with a strong international standing if and when an opportunity arises.

5. Recommendations

Based on your overall observations and analysis of the department, please provide the recommendations that you find most useful to the department for the future development of high-quality research and research environments

- Continue high-level basic research across mathematics.
- New Math in Data and AI division has a lot of potential! Develop strategy/vision, support with hires.
- It is currently difficult for potential industrial collaborators to identify the correct research point of contact. Perhaps highlight ‘impact-cases’, or a department-wide industrial seminar.
- Facilitate Department-wide support for industry engagement.
- Implementation of Department-wide accounting of faculty workload.

- Reflect on the current Division structure. Do the existing Divisions continue to serve the many academic needs of the Department?
- The same recommendation as in the previous RAE - to develop a cohesive strategy in the smaller divisions, and to then augment the faculty research groups so as to achieve critical mass - is reinforced. Implementation of this recommendation is related to the previous one.
- Participation in the sabbatical programme should be encouraged.
- Recruit at all levels: senior faculty to start new research directions, junior faculty for growth.
- Speed up recruitment processes.
- Consider increased collaboration across KTH.
- Apply for ERC grants.

Specific issues

1. Research profile and quality

a. Central research questions and themes, and main research activities

The research activities of the Department of Mathematics are organized in five Divisions:

- Division of Mathematics
- Division of Mathematical Statistics
- Division of Optimization and Systems Theory
- Division of Numerical Analysis
- Division of Mathematics of Data and AI (formed in 2020)

- The Division of Mathematics is by far the largest and covers broad areas of modern mathematics, which can be divided into the following seven research topics: Algebra and Geometry, Combinatorics and complexity theory, Differential Geometry and Mathematical Physics, Dynamical Systems, Number Theory, Harmonic Analysis and PDE, Random matrix theory and stochastic models.

- The Division of Mathematical Statistics can be divided into the following four areas: Probability theory, Stochastic simulation, Statistical learning and data analytics, Financial and insurance mathematics.

- The Division of Numerical Analysis can be divided into three areas: Partial and ordinary differential equations, Stochastic differential equations and Numerical linear algebra.

- The Division of Optimization and Systems Theory consists of two areas: Optimization and optimal control and Mathematical systems theory.

- The Division of Mathematics of Data and AI was established in 2020 and is still under construction.

The Department of Mathematics at KTH has a very strong tradition of international excellence in pure mathematics and is very innovative in applying mathematics to applications in business and society. There are many excellent mathematicians in each research area. Several faculty members have received awards and prizes, such as an EMS prize, the Knuth Prize, an ERC Consolidator Grant, and an ERC Consortium Grant. In addition, five faculty members were invited to speak at the International Congress of Mathematicians.

The panel is impressed with the results, which have had a major impact in their respective fields, both in theory and in practice.

b. Contributions to the advancement of state of the art within the research fields of the department

Areas with very high research quality and important contributions to the advancement of the state of the art in their research areas include Algebra and Geometry, Combinatorics and Complexity Theory, Random Matrix Theory and Stochastic Models, Numerical Analysis, Harmonic Analysis and PDE, Mathematical Statistics.

Some groups have made significant contributions to industry and society, as shown by the following notable impact cases:

1. Modelling and optimization for radiation therapy,
2. Topological data analysis of life science data,
3. Scientific machine learning for image reconstruction in medicine,
4. Rational design of social policies.

The progress in research and application is partly due to the external funding (in particular the KAW Mathematics program since 2013, Wallenberg WASP program since 2014 and the Brummer & Partners MathDataLab since 2017), which has also increased the number of postdocs in the department and led to an even more research-intensive environment.

The Panel congratulates the department on the very large increase in external funding in recent years.

c. Quality and quantity of contributions to the body of scientific knowledge, engagement in national and international research collaboration within academia and its outcomes

It is the department's claim to actively strengthen the central and steadily growing role of mathematics for science and society and to make fundamental contributions to the subject. In terms of this goal, the department has been very successful.

Several rankings show that the department enjoys a very good reputation internationally (e.g., in the Shanghai Ranking 2020 and in the QS Ranking 2021). Some faculty members have key roles on international committees. Faculty have presented plenary lectures at premier international conferences and workshops (e.g., ICOSAHOM, European Congress of Mathematics, SIAM conferences, MSRI, ISAAC). This is an indicator of the high international reputation of the faculty.

Faculty members of the department already have extensive international collaborations. Internal collaborations could be further strengthened if desired.

d. Follow-up from previous evaluations

In RAE 2012, core recommendations included:

1. developing an undergraduate major program,
2. securing stable funding to anchor doctoral programs and research time for associate professors,
3. increasing the number of faculty in support of some Divisions.

In response to Recommendation 1, the Department created the 5-year Engineering Mathematics program. This is already successful and is attracting both high numbers and excellent students.

Several issues raised in the previous RAE remain and appear largely outside the control of the Department.

The Department is very clearly successful at raising external funding, but this cannot be considered stable funding for doctoral programs. For example, this model ties students to externally-funded research projects, and prevents them and the faculty from pursuing ambitious, deep projects or new collaborations. The Department has tried to mitigate the uncertainty by creatively distributing internal funding to support research activities. It has formed partnerships with interdisciplinary centres such as WASP, Interface and Flow. While these are excellent initiatives, without stable internal funding KTH is still not helping its researchers pursue and incubate high-risk ideas.

Recruitment regulations at KTH are clearly stifling the Department's ability to replace retirements, let alone grow the Department. Particularly in some areas of mathematics, the university is competing for academic talent on a global scale. A process which takes several months longer than in peer international departments is having a clear negative impact. It is impossible for units to develop strategies around responding to new academic areas, or strategic hires. The Department is trying to streamline, from its side, by considering pooling job searches, or broad ads. This will alleviate some of the acute pressures, but is entirely inadequate without KTH-level support. Similar to the previous RAE recommendation, we see that improving recruitment strategies must be a KTH priority if long-term competitiveness is a goal.

A related issue appears to be faculty retention. While the Department has actively tried to secure stable working conditions, we identify two key outstanding issues from the previous RAE: stable working conditions and very high teaching loads. These are tied to KTH regulations. Particularly in fast-moving fields, we see hiring of senior faculty under these conditions as an ongoing challenge.

2. Viability and research environment

a. Internal and external funding; current status and strategies for the future

Available internal funding is not adequate to the needs of the department. We noted an extreme dependence (relative to international peer departments) of the doctoral programs/PDFs on external funding, and the consequent risk to the continuity of these programs. KTH senior leadership needs to urgently examine the research and training impact of these policies. There is a true tension between the availability of internal funding and the need to secure external funding, which is then reflected in tensions between time allocated to externally-sponsored research compared to stably meeting teaching and administrative needs of the department.

Regulations around teaching for Assistant Professors biases hiring in the direction of senior hires, which in turn are more expensive. Given these factors, this appears a problematic funding model. Considerable energy appears to be dedicated to identifying new external sources of funding. There is a strong reliance on VR funding in some groups. In others there is more diversity of external funding. ERC grants are under-represented given the extremely high quality of the department. The strategy appears to be to respond to opportunities as they arise.

b. Academic culture

The department has an enviably vibrant academic culture, including many research seminars, involvement in organizing workshops and conferences, and discussions across division boundaries. The Mittag-Leffler institute serves an important role, by providing mechanisms for even more visitors.

Students, faculty and postdocs seemed near-unanimous in their assessment that the department was a collegial place.

It was noted that the primary contact of the students with the Department was through the supervisor. This includes interactions on career development, administrative help and soft-skills development. While there are no currently identified problems, we encourage the Department to revisit the current arrangement. For instance, yearly workshops on career possibilities in the Math Sciences, technical writing, and other student-centered activities could be useful.

c. Current faculty situation and composition of the research team(s)

The research teams are organized into Divisions, the role of which is unclear. Division boundaries seem historical in nature, rather than responsive to current intellectual synergies. It isn't clear the current faculty themselves would organize themselves in the same way. This could be fine as long as the Divisions don't play more than a social/informal mentoring role. There are research commonalities across Divisions (e.g., in the AI/data science sense). There is considerable heterogeneity in the size of the Divisions as well, the need for which is again not apparent. The new Math in AI Division will clearly require the introduction of new courses and potentially new programs, but how this is to occur within the existing structure is not clear. We heard mention of "borrowing" teachers for courses between Divisions which further indicates that there might be some better way of organizing the department.

Faculty size is inadequate for the teaching carried out within the unit. 10 new hires are in the pipeline, but this will just about meet current teaching needs. There is a clear challenge in terms of introducing new courses and programs.

d. Recruitment strategies

Our primary recommendation is for KTH to audit and improve its recruitment processes. Why are they so slow? They make the university less competitive, particularly for international candidates. Another recommendation: the internal/external funding balance does not seem sound, and is contributing to unnecessary stress it seems in terms of how much energy faculty can devote to university matters/external research.

Broad ads (as opposed to targeted ads) are a good idea. This is perhaps an opportunity for 'cluster' hires? There are possible efficiencies to be found. On improving gender representation: the department has taken many proactive steps, and the impact is visible in the junior ranks.

e. Infrastructure and facilities

These are excellent, and support the research/teaching mission. Access to Mittag-Leffler is also an advantage.

3. Strategies and organisation

a. Goals for development 5–10 years ahead

The department aspires to be a research environment that continues to produce excellent research within a broad range of the mathematical sciences and attracts excellent researchers, with an internationally leading role and visibility in an increasing number of research areas. The strategy for creating an excellent research environment consists of facilitating research discussion and dissemination meeting places, having a large proportion of faculty engaged in many types of projects, and with a high level of external funding.

If the department is to deliver on the goal to develop and maintain faculty, KTH's recruitment process needs to be faster and to better take into account upcoming recruitment needs. The current structure with limited internal funding of research must be revisited to ensure that the department continues to be an attractive employer.

b. Congruence with university-level goals

The vision formulated by the department; to have many excellent researchers in a thriving and open research environment, is an enabler for ground-breaking research. The department strives to continue to improve on the research environment to make the department a top choice employer for international mathematicians, and one fundamental ingredient is to hire faculty with a balanced gender distribution. The Department's goal to increase both local collaborations in the Stockholm area and internal collaborations should further increase the participation in interdisciplinary projects, and thereby in projects that are central both to digitalization and sustainability. One specific goal listed under the headline of "Mathematics for AI and Machine Learning" is to promote collaborations that include development of new mathematical theory for AI and data, which aligns perfectly with this cited KTH goal as the interdisciplinarity will be enhanced by an increased mobility between academia and industry

c. Leadership structure and collegial structure

The faculty, postdocs and PhD students expressed appreciation for the collegiality of the smaller divisions. The balance of a large Division of mathematics and several smaller others creates different organizational structures, where the Division of Mathematics has a coordinating function not needed for the smaller divisions.

There are other less formal collegial structures in the department, such as research groups that are formed around common interests, but with no formal leaders. The department also has more formal structures, such as the Brummer & Partners MathDataLab initiated by the department leaders, and the WASP assistant professorships with a mix of bottom-up and top-down discussions.

d. Strategies for achieving high quality

The current research environment allows for everyone to develop and thrive. Faculty successes in both research, visibility and publications are, or are planned to be, announced to the entire department. Increased internal collaboration should increase applications for external grants, further increase the international visibility of the department and attract excellent researchers to the department. The current long recruitment process may raise obstacles to recruit researchers with a strong capacity of producing high quality research.

There are several incentives for each individual to set their goals high: external funding and publications in prestigious journals are encouraged. The limited internal funds are used, to the extent possible, to enable faculty to stay research active in the absence of individual external funding. The limited internal funding may make it harder to take the risk to work on a truly challenging problem where the outcome is uncertain and external funding is lacking. More internal research funding would allow more flexibility in this respect.

Dissemination towards industry is mainly achieved through collaborations with industrial partners and through PhD students that graduate and start working in industry. Recurring industrial collaboration workshops could further increase the industrial commitments.

4. Interaction between research and teaching

a. Interaction between research and teaching at all three levels (B.Sc., M.Sc., Ph.D.) of education

Research in the department is incorporated to teaching on all three levels (B.Sc., M.Sc., Ph.D.) in various ways:

- Bachelor thesis and Master thesis projects (around 100 each per year) are proposed and supervised by faculty, postdocs and PhD students.
- Advanced master students are encouraged to take PhD courses.
- The master and doctoral programs of mathematics and applied and computational mathematics are done jointly with Stockholm University thereby exposing the students to a wider range of research fields.
- New 5-year engineering program in Engineering Mathematics with 30-40 students strongly stresses the connection of research and education at the department. The program has a seminar series where invited researchers give presentations about their research for the students.
- The new track Mathematics for Data Science within the master program in Applied and Computational mathematics is tightly connected to the research programs.

In the previous evaluation in 2012 the Division of Mathematics was suggested to secure stable funding to increase the size of the Doctoral program and to ensure that the associate professors have sufficient time to develop their research program. The number of PhD students has increased since 2012 but their funding comes from external grants which leaves the doctoral program vulnerable. We recommend the Division to continue with the efforts to secure more KTH funding for departmental costs and thereby for the doctoral schools.

It is good that Bachelor theses are supervised by all the research personnel thereby possibly introducing these students to research in the department. One suggestion is to provide research internship opportunities for the summer for the undergraduates.

In terms of student retention, the doctoral students in the unit appear to stay in the program, and complete within an average of 48 months. Across KTH retention in the 5-year and MSc programs is not great. Within the Department, the new 5-year Engineering Mathematics program is too new to present complete figures.

In terms of student career outcomes, fine-grained data is not available from KTH. Within the department, the future employment of graduates was indicated as:

Master program in mathematics: 50% academia, 50% industry/government. Master program in applied and computational mathematics: 90-95% industry/government. Less than 10% (maybe 5 %?) continue in academia. Doctoral program in mathematics: Large majority of students continue in academia at least for a postdoc. Among the 12 most recent graduates, only 2 went to industry. Doctoral program in applied and computational mathematics: Maybe 30% academia, 70% industry, at least among 15 most recent graduates.

5. Impact and engagement in society

a. Relevance, scale, and impact of the department's current engagement with society and industry

Several research projects are pursued jointly with industrial partners involving industrial PhD students, postdocs, and adjunct professors. They are not only in applied mathematics but also involve fields in pure mathematics such as algebraic topology, algebraic geometry, geometric analysis, and combinatorics. Likewise, around 100 master thesis projects each year are done in collaboration with industry.

Recently two major initiatives have been started that aim to connect pure and applied research to life sciences and artificial intelligence. In life sciences this has led to collaboration with Karolinska Institute applying pure mathematics (topology, algebraic geometry, combinatorics) and statistics to the analysis of chemical reaction networks and genomics data and research in analysis, differential geometry, optimization, machine learning, and numerical analysis to applications in biomedical imaging and image guided therapeutics. There are now extensive collaborations within these areas that involve both clinical (Karolinska University Hospital and Cambridge University Hospitals) and industrial stakeholders (Novartis, AstraZeneca, Elekta, RaySearch Laboratories, Philips Healthcare, Siemens Healthineers, and Thermo Fisher Scientific). We were particularly impressed about the algebraic topology project.

In artificial intelligence (AI) the department has taken several initiatives. In 2015 it established the Brummer & Partners MathDataLab (MathDataLab), a centre that focuses on mathematics of complex data with the help of external donations. In 2017 within the Wallenberg Foundation WASP national research program for AI the department focuses on understanding of the mathematical principles behind AI. The WASP funding allowed the recruitment in 2018-2019 of four assistant professors. We believe this initiative has great potential and cuts through all the fields of research in the department.

b. Research dissemination beyond academia

Jointly with Stockholm University the department organises outreach activities towards middle and high school (the Mathematics Club and the Mathematics Circle). PhD students are trained and conduct projects in programming and mathematics with high school students and their teachers. The department is also involved in developing course modules for mathematics teachers. Faculty from the

department take part in outreach activities towards the general public (Sonja Kovalevsky days and the Pi-day organised by Stockholm Mathematics Centre). Faculty has also been involved in writing briefing and policy papers on life sciences,uncertainties in the SIR-model for Covid-19 spread and electoral manipulation. All in all, this is laudable but rather standard these days. For instance, the creation of industrial collaboration workshops could create a broader impact on industry developments. As a side benefit, this could enable current students to learn about interesting opportunities in industry.

Today collaborations are to a large extent dependent on whether an alumni of KTH is employed by an organization and manages to maintain their contacts with KTH. At the same time industry is increasingly aware of the need of tying themselves closer to research, perhaps especially in the AI and digital applications space. If the Department had facilitating functions to create well-known meeting opportunities on a recurring basis this would be very appreciated by industry and could very well lead to grants both from Vinnova, VR, WASP and ERC. One theme observed by some reviewers is that colleagues in the Math Department viewed themselves as “in service” to other more applied researchers - claiming that they are at the mercy of others to get involved with this research, undoubtedly feeling that they don’t have sufficient application expertise to make contributions without other collaborators. While this is an understandable concern, there is no reason a Math researcher could not reach out to others to initiate collaborations. This would also be an excellent way to get more involved in direct work toward SDGs.

c. Relation to sustainability and the United Nations’ Sustainable Development Goals (SDGs)

As expected for a department with a high profile in pure mathematics, less than 20% of research is directly related to SDGs, mostly research related to life sciences and research in statistics. In the department targets on Good Health and Well-Being goals, good examples are cited such as helping public health officials and the public understand how to think critically and with higher level mathematical concepts (a concept they call “numeracy”) about COVID-19 data. This emphasis on numeracy, or numerical/mathematical literacy and logical thinking, is commendable and could be applied in other ways to other SDGs. It could be a unique way for the department to position itself to potential collaborators and partners.

d. Plans and structure for increased impact

In outreach a new option that is being considered is to allow for “summer internships” in which selected students (undergraduate or high school) take part in a project with researchers at the department.

The department is planning to establish a structure to facilitate external collaboration especially in Life sciences and AI possibly building this on MathDataLab. These plans are still vague, and we encourage pursuing this.

6. Recommendations for strengthening the department and its future potential

- Refer to research recommendations in the Major Findings section.
- The auditing and improvement of KTH recruitment processes is strongly recommended.
- The auditing and improvement of the KTH internal funding model is strongly recommended.

- The retention and employment prospects of students should be better tracked at KTH. There appears to be some issue with retention at the master's level which is not unique to the Department?

- Divisions seemed to be organized by teaching/history, varying in size. Reflect on the Division structure. What role (research, teaching, academic environment) does this structure serve? Is there a modernization or update which could be of use? We deliberately refrain from offering a prescription. The Department is very clearly engaged in superior research activities, and members report a collegial environment. There is no particular issue which warrants a reorganization. Rather, such an exercise of structural reflection is perhaps useful when things are running smoothly.

- There is potential for better incentivizing/promoting application-driven work. This, however, requires support and encouragement from the Department in terms of appreciation of such efforts, and perhaps venues to facilitate them. Perhaps Department-wide seminars where colleagues from other KTH departments are invited, who do not yet have collaborations with the Department of Mathematics?

- The Department is encouraged to allow some dedicated time for 'future research' discussions; allocating some time for faculty, both individually and in groups, to work on setting up research directions together.

- The use of the new sabbatical programme should be encouraged.

- The recruitment of faculty at all levels remains crucial. The Department is strongly encouraged to recruit beyond the bare minimum numbers required to maintain teaching capacity.

- The establishment of Departmental level support for career development/mentoring of students is encouraged.

- There is some concern about how potential conflicts are handled, and the creation of a Departmental Ombudsman is suggested.

- The Department members are encouraged to more actively apply for ERC grants.

7. Final remarks

In addition, state if the panel lacked any material relevant to making adequate observations and recommendations.

The Department of Mathematics at KTH is world-class. We commend them on their continued research excellence and encourage the University to support the Department to maintain its international prominence.

The unit strives to maintain an academically exciting and supportive atmosphere, and the experience of the students is positive.

Most significant concerns we had could be traced to KTH-level policies. These were echoed at the Board meeting by other Panels, suggesting a systematic concern.

Overall, we were able to access the material we needed, and commend the coordinators for their help in answering questions as they arose. We also thank the department for their enthusiasm and transparency, and compliment them on a highly successful academic enterprise.

Department of Engineering Mechanics

Major findings

1. Strengths and weaknesses of the department

Strengths:

- Research in Dept of Engineering Mechanics is high standard, in which some divisions, and their respective faculty, are recognised as world-leaders.
- International academic and industrial collaborations are excellent and include high-profile EU projects.
- Industrial interaction is commendable strong.
- Participation in several research centres and platforms within Sweden that provide multidisciplinary research opportunities not only nationwide but also internal to KTH.
- Excellent external funding, from diverse sources. This includes ERC grants and other high-profile sources.
- Connecting postdocs through thematic areas, across the divisions is effectively achieved via the initiative to fund postdocs co-supervised by faculty from different divisions.
- Infrastructures and lab resources are excellent. Consolidation efforts for management and maintenance of experimental infrastructures are excellent.
- Enthusiastic and proactive leadership, steering a new department, which results from merging three departments with diverse structure and heterogeneous practices.
- The ability to consistently rank research in the TRL scale, thus providing the Department with the quantitative means to define a metric in which strategy and decisions can be based.
- Impressive number of patents and involvement with start-ups.
- Post Docs systematically reported KTH as a very attractive place to be active at.
- Extent of sustainable transport research across a wide range of different vehicles is very good, having a very high potential to identify and address common challenges that can be exploited externally or internally.

Weaknesses:

- Publication productivity is of concern not only because a clear list of preferred top journals does not seem to be disseminated yet but also because conference proceedings and other forms of non-peer reviewed (or weakly reviewed) seem to be used as publication means in equal terms to journal publications.
- There is an additional concern that in some groups PhD students are pushed to publish more at the expense of a focus on quality by focusing on conference proceedings as an alternative to peer-reviewed journals (conference proceedings publications are necessary but as a complement to journal publication and not as alternative).

- The industrial sources of funding are mostly based on classic industries with a relatively low incorporation of funding from emerging industries or technological sectors. This may be an artifact of the current structure for which a 'watchdog' group, maintained in the department structure, may allow identifying specific opportunities, or even foster new opportunities.

- The supervisor (or academic advisor) seems to be the major hub of networking and interaction for the majority of issues that concern PhD or postdoc researchers. Although this works very well as long as both the relation to and the job done by the supervisor is good, it's a potential weakness for the PhD-students and postdocs. Parallel channels would strengthen the community and the department.

- Fragmentation is a concern as: different sizes of units, some of which being quite small, lead to very heterogeneous funding performance; too many levels of departmental structures; research culture (including how quality is assessed) is heterogeneous inside the department.

- Mentoring of new staff is informal, and although it seems to be working well, poses risks when a research group, faculty or department structure has to overcome unforeseen changes.

- A natural tension with administrative load for the centres and/or department and research efforts exist and are not solved, neither a strategy to address them is in place. Instead, a clear load sharing model that balances research, teaching and administrative activities can support strategic and day-to-day decisions.

- Very slow recruitment processes results in: missing opportunities of hiring top selected candidates (they go elsewhere); not encouraging candidates to apply; relying on external committees.

- Technical laboratories seem to be understaffed.

- High attrition in the permanent staff: loss of 21 permanent staff (several substituted by temporary positions). Balance between permanent/non-permanent staff, technical staff is not clear.

- Management structures lack representation from technical staff/postdoc groups with the information flow depending upon the supervisor. There is no clear process to overcome issues if things break down.

- Top-heavy distribution in terms of seniority.

- Equality issues in general and gender-related workplace issues in particular, seem to be addressed in an informal way. Monitoring equality issues permanently, even if they do not exist or have not been reported (which is a statistical abnormality considering the Swedish statistics) is expected.

2. Relevant and forward-looking objectives

As an internationally renowned and excellent department, societal impact activities have the potential to be developed further. The current status is already of a very high standard but relies to a rather high degree on the opportunities identified by either external 3rd parties (e.g., companies) or internal entrepreneurial faculty, to turn high functional capabilities towards solving problems in different

organisations or parts of society. This approach will lead to a kind of excellence - capability - implementation downstream relation.

At the same time major institutions like the European commission and cutting edge companies have introduced a *challenge based* approach in much of its work, identifying "how done looks like", trying to reverse engineer the necessary scientific questions to be answered to reach the required state. For the department, this approach could provide a golden opportunity to further its societal impact even more, and also influence both the recognition and prioritization of scientific problems by different bodies in society.

Are the goals relevant and forward-oriented?

A lot of the aims and objectives (how the department reaches its aims) are quite vague and are focussed on doing more of the same but stating "let's do it a bit better". The aims "to be one of the most exciting places in the world where we have disciplinary excellence in core areas that are the names of the divisions - fascinating demonstrators and high and low TRLs and links with industry are strong" is not at all inspiring - where is the big picture to tackle and solve the big societal problems, impacting on industry and society? There is nothing inspirational at all. Similarly, the objectives (numbered goals) are very wishy, washy and don't say how they will be done. A major re-think to the aims and objectives is required which is a function of a more precise vision of where you want to get to in the next 5, 10 years timespans.

Regardless of which objectives the department will develop, a key aspect of achieving them is the choice of relevant key performance indexes in order to track and follow the fulfilment of the set targets. If the department is to gain the approval of the university management (and to gain further investment) for other objectives than straight forward bibliometric ones (that the KTH central library can provide on their own) it is vital that progress can be demonstrated in a systematic and successful way. Hence, the measurability, and especially composite measures of different aspects that take collaboration, societal impact and broader dissemination into account, could be an objective in itself in the future development of the department.

3. International community engagement

The engagement of the Department in the international academic community is good, based on the large (and rising) fraction of its publications (now around 55%) issued from international cooperations with good ranking universities or institutes from various countries (United Kingdom, United States, France, Germany, and many others). Besides, a significant number of keynote lectures have been given in international conferences by members of the Department, especially in fluid mechanics, acoustics, mechanics of polymers, elastomers or hydrogel, rail vehicles, AI, and engineering education. Over the past five years, several faculty members took an active part in the organisation of international conferences or sessions/mini-symposia in larger conferences, especially in computational mechanics, fluid mechanics, acoustics, vehicle engineering.

On the other hand, the co-publication list clearly identifies Swedish companies as the majority of non-academic organizations for collaboration. This is partly explained by the national character of available funding for industry collaboration, but the committee encourages the department to pursue the possibilities of more pan-european setups in the Horizon Europe program, as well as other funding possibilities. It is also our recommendation to try to pursue "extra Scandinavian work packages" in such projects.

A much stronger push on sabbaticals is also advised, coordinating across the Dept, sharing the teaching load (or having only 6 month sabbaticals, so that teaching is not missed) and exploiting the new KTH funding for this. Such sabbaticals should become part of the career plan for all academics.

4. Future potential of the department

The department has both excellent lab equipment, several leading research groups and a genuine societal impact. This not only is a status that needs to be maintained, and eventually reinforced, but also it is a 'role model' that gives the Department extra responsibilities to guide its members.

There is a rather strong indication from the interviews with PhD-students and postdocs that the structure of non-core scientific guidance holds a potential for improvement. Issues like advice on career planning for the postdocs (who have a two Year contract and, afterwards, have to compete for positions on companies or Universities), help and guidance in teaching or usage of the equipment is fractionated and highly dependent on the relation and the ability to help of the supervisor. The PhD-students solved many of these issues amongst themselves in a good way, but there seems to be a potential for a more systematic and efficient support, freeing up time for core duties. The postdocs, being part of the potential new faculty at KTH and other leading universities, or valued members of non academic organization, could benefit greatly from a systematic support in career planning, but also systematic documentation of teaching and supervision efforts.

Funding for new equipment seems to be rather 'easy' to secure. However, its maintenance and the space rental costs seem to be a problem. There is no plan for what new equipment is needed and it seems very haphazard depending upon individual academics. Support for operating the labs seems to lie a lot with the postdocs and PhD students, who are only temporarily at KTH. Planning for new equipment and its installation and maintenance costs support and eventual reshaping of Laboratories should be part of the planning for "identifying emerging areas" and "research infrastructure" goals.

Joining things up to produce a coordinated solution of society's problems, with reference to UN goals, should be made much clearer rather than sticking to individual disciplines.

There is additional potential for the department to tap into the matter of gender and inclusiveness. Although the impression is a very good culture at the department, very good support for parental leave and inclusiveness regarding different backgrounds, it could be helpful to introduce more dedicated tools such as surveys and a neutral but scientifically knowledgeable 3rd party "ombudsperson". This could further the attractiveness even more and also help improve the gender balance in the faculty. Note that due to the visibility of the Department in the European, and World, landscape it is also a role model in aspects such as inclusiveness.

5. Recommendations

The department has many strengths but is still somewhat of a heterogeneous conglomerate of historical (sub)units from previous organizational setups. This is only to be expected considering the recent reorganization, but one vital aspect of going forward as a new and strengthened department is to consolidate these structures. In practice this means a deeper discussion on the subject of critical mass, which groups and centres may lack mass and how to address this issue. There are most likely a number of different routes to a more homogenous department - *not* involving any new re-organization - but it is our recommendation that the department tackles this problem since it risks diminishing both excellence and relevance in the long run if left unattended.

On a related note, the panel also notes a potential in extending the collaboration both with the Mathematical and other KTH departments, where not done via research centres. Such intra-KTH collaborations have potential dual usage in both broadening the scientific possibilities as well as societal relevance, and in addition alleviate some critical mass issues (an isolated group may be subcritical, while the same group in a matrix collaboration may be not)

The panel furthermore recommends the establishment of a long-term plan on (re)new(ed) scientific areas, and which traditional areas to maintain/eliminate. Genuine reflection on emerging areas, and the quality of existing areas, characterize a healthy research environment. The Department has a unique opportunity at this juncture to help define the cutting edge of the discipline within KTH as well as more broadly in society. The new Thematic Areas provide a good framework for this discussion, and we recommend the department to especially focus on societal problems (UN). In such a process we think it is important to identify wanted academic and research values and outcomes which encapsulate the range of departmental activities - including patents, IP, spin-offs and start-ups, in addition to high-quality publications. Future planning should also include consideration of experimental facilities, and some set of metrics in order to monitor quantitatively the scientific production of the researchers and research groups.

Turning to more practical issues, we note a clearly asked for a generally implemented staff loading model. PhD-students and postdocs reportedly had found ways to cope with and manage many issues themselves, but there is clearly room for more systematic approaches.

Several (most) respondents during the interviews also identified the needs for more specialised administrative support, in particular for support for grant applications and project administrative reporting. One way to address this issue is to create a small overhead on existing projects to serve as matching funds to any central KTH support that may be secured.

Departmental level support for career development/mentoring of students and postdocs could become more systematic and less dependent on the supervisor as an individual.

Technical staff and postdocs (generally non-faculty, non-PhD-student staff) seem to lack representation in the department's different organizational bodies. In order to accelerate inclusiveness, these staff categories should be included in a suitable way.

The department should furthermore consider the introduction of faculty surveys for gender and inclusiveness issues together with a neutral 3rd party "ombudsperson" to circumvent any potential catch 22 effects relating to individual supervision situations.

Concerning the attractiveness of KTH, postdocs and PhD-students reported that they viewed KTH as very attractive and that they would be very happy to recommend KTH to their friends. However, faculty members pointed to the difficulties to hire faculty (especially professors) and cited among other things the lengthy recruitment processes (up to three years!). It is the panel's perhaps strongest recommendation to genuinely address the speed of said processes in order to keep KTH attractive to internal top faculty members.

A more systematic usage of a sabbatical programme is also encouraged (using KTH funding) to increase attractiveness as well as international collaborations and relations.

Specific issues

1. Research profile and quality

a. Central research questions and themes, and main research activities

The department results from a recent merger between 3 departments, each one of them with a particular culture and success research cases. One of the measures to strengthen the new department has been by develop synergies by forming teams of researchers, from at least 2 of the former departments, to address common research themes and, eventually, identify new emerging research areas. In time, this will not only add to the internal research coherence of the department but also to set directions for addressing new research opportunities and reflecting in existing research areas that become less vibrant.

Research in the Department of Engineering Mechanics (DEM) is very much oriented towards societal needs and industrial applications. This is an asset when it comes to finding funding and attract students. However, as the self-evaluation report refers, a balance should be kept with more fundamental and prospective, curiosity-driven research being the use of the TRL scale a good tool to evaluate the balance that the department aims at.

The department is very strong in many of its research fields, which is observed not only via the attraction of ERC grants, funding of high-profile research centres and success in securing large scale competitive projects at the National and International level. The output of the research carried at the DEM results not only in its researchers being invited for Keynote lectures in prestigious Conferences or highly visible scientific publications but also in industrial patents and start-ups, which are important measures of achievement.

The list of research themes and groups is very heterogeneous, both in size and in topics. Also, the content of the Solid Mechanics unit is very heterogeneous. Some of the themes seem to have only evolved incrementally over the past 15 or 20 years. Even though a certain continuity in the activities allows to keep a broad recognition, the renewal of research themes should be encouraged.

b. Contributions to the advancement of state of the art within the research fields of the department

The experimental facilities of DEM (Odqvist Lab, Marcus Wallenberg Lab or the Moveability Lab) and the computational Laboratories (either distributed or based on supercomputers and highly parallel computing architectures), the partnerships for experimental facilities fostered via the research centres in which DEM is involved and an healthy and robust funding landscape, ensure that the department secured most of the tools necessary to promote excellent research with cutting-edge cases.

Monitoring of the effective advancement of the State-of-Art of the research in DEM via credible impact measuring agencies (SCOPUS or ISI) and International Rankings provide independent indicators for the performance and impact of research and support the steering of research activities at a Departmental level. Currently, there is a pro-active effort to identify strategies and engage in challenging research questions (the approach to address multidisciplinary research topics in DEM via Thematic Areas involving two or more research groups or the involvement in multidisciplinary research centres is an excellent example). As the ability to continuously increase resources and research personnel is limited, therefore the continuous monitoring of research areas and topics that become spendable, or even obsolete, is recommended.

c. Quality and quantity of contributions to the body of scientific knowledge, engagement in national and international research collaboration within academia and its outcomes

This is actually quite impressive, the DEM has existing international collaborations, as well as a large portfolio of high-profile companies with which research contracts are active. Their expertise is clearly valued. The DEM seems self-critical in terms of what constitutes 'research' and may benefit from appropriately evaluating/valuing Intellectual Property and patents.

It is problematic that some groups experience pressure to value quantity over quality for refereed contributions and, in the process valuing in the same basis peer-reviewed journal contributions and conference proceedings (regardless of these being refereed or not). This is not a winning strategy, and can actually damage the research reputation, but that can be overcome.

A rising fraction of the publications (recently higher than 55%) is issued from international cooperation with good ranking universities or institutes from various countries (United Kingdom, United States, France, Germany, and many others). This is an indication of the quality of the research developed at the DEM. However, it is worrying that between 2017 and 2019, the average number of papers in peer-reviewed journals was weak: 1.3 to 1.6 per permanent academic per year.

d. Follow-up from previous evaluations

The department, in its self-evaluation, presents a detailed account on the follow-up of previous evaluations. But being the merger of the three previous departments one of the most impacting and having this been implemented a bit more than one Year ago, in a period of pandemic, it is not yet possible to appraise the full results of this change. However, some particular results of previous evaluations are being implemented already.

Concerning patents issued from research in the Department, it is mentioned "innovations get patented by our industry partners". Why not by KTH itself? The department, and KTH, are launching efforts to better explore the innovation by their researchers and obtain better value for their patents, via commercial agreements and start-ups. In any case, we are aware that the researchers own their IP, but it is often more convenient to do the patenting via companies. KTH supports patenting but can't own the patents by itself.

The results of the suggested effort to recruit academics educated abroad have been modest (1 assistant professor) in applied mechanics as a whole, but more significant in fluids mechanics (2 out of 3 assistant professors, and the third one spent time in foreign universities before returning KTH). The recent opening of an assistant professor position in nanostructured bio-based materials is a good idea, and might favour interactions with the Material Science and other Engineering Depts, eventually via the Centres in which both are involved.

The area of Biomechanics has active researchers in the more classical areas of solid mechanics, fluid mechanics and mechatronics. There are common mechanisms of dealing with experimental issues, ethics and partnerships with health or sports oriented centres that suggest keeping some common structure in place. A transversal monitoring/overviewing of activities in Biomechanics is recommended.

2. Viability and research environment

a. Internal and external funding; current status and strategies for the future

There is a very good amount of external funding from a range of different sources and interaction with industry. The research environment is appreciated by all the PhD and postdocs we talked to, and they thought that the environment was extremely conducive for developing research ideas. Most of the postdocs seemed to be working on funding that allowed them to develop research ideas without much pressure, compared to those working on industrial and H2020 projects who have to be very project focused.

There are excellent experimental and computational facilities though there doesn't seem to be a great number of technicians to support the facilities - most of the expertise seems to be passed on by osmosis between the researchers with little input from the academic staff. This process has a high risk if there is a drop in the researcher population. The number of postdoc researchers has increased a great deal in recent years - a number of worries were voiced that if the funding dies up they will lose them all (they are all on 2 year contracts) - but the same people would be worried if they didn't have the funding and therefore didn't have the current body of researchers.

Strategies for the future are a bit vague. It is not clear how the big societal questions are being answered across the department in a collaborative manner. There seems to be no mechanism for the development and support of new facilities or how new research areas are identified and then exploited.

b. Academic culture

The academic culture appears to be evolving after the merger and the Department is to be lauded for its efforts to try to make this process smooth. There are clearly competing unit cultures around what kind of research activities are valued, publication venues and goals, and funding issues. These issues will require ongoing discussion. At the same time, spending too much time on trying to 'keep the peace' appears to come at the cost of moving forward cohesively. There isn't a perfect balance, of course. An opportunity presents itself to reinvigorate the department through new hires, and perhaps trying to not slot them into pre-existing units; the 4 thematic areas are an excellent idea in this regard. One potential risk is that the academic culture with the postdocs and PhDs relies totally on the relationship with the supervisor; although no examples were cited, if the relationship breaks down there is a danger that the student or researcher will not complete their thesis/project.

There are concerns about the work environment for women which were raised by some of the people we talked to. Reports of eventual abuses at the Math and Engineering Mechanics departments are very low, or non-existent, when compared to the percentage of cases reported in other similar Universities in Sweden. Thus, a continuous monitoring of eventual unreported cases is advised. Maybe this is a department which is honest about these issues, and isn't especially dysfunctional but, on the other hand, it seems the research and teaching environment is not inclusive. The department may wish to continue ongoing candid conversations about this, and address workplace culture/workload issues as a priority. Compared to other countries in Europe and further afield the Department, and indeed KTH, are only starting to consider gender issues; much more work needs to be done there, and notice needs to be made of other diversity issues.

c. Current faculty situation and composition of the research team(s)

There has been **a lot** some attrition in the faculty membership but no explanation as to why this has happened. Between 2012 and 2020, a decrease in the number of associate professors (from 28 to 22), assistant professors (from 11 to 4), adjunct professors (from 7 to 1) and research engineers (from 26 to 12), with an increase in Full Professors (from 24 to 36), was observed, that is a total of 21 less faculty members. In the meantime, the number of postdocs increased by 18. Replacing with postdocs and researchers keeps the body count the same, but is no substitute for permanent faculty. A strategy is needed to replace the academic body and to focus on developing areas, attracting further support from the University.

The Department is still very top heavy in terms of the number of full professors approaching retirement. However, the department has an excellent record in hiring faculty with very high potential, as it is demonstrated by its 4 ERC grants. A careful definition of strategies to balance faculty renewal with the identification of emerging and fading research topics is advised.

d. Recruitment strategies

As far as possible, recruitments on permanent rather than on temporary positions (such as postdocs) should be favoured. The condition about the ability to teach in Swedish within 4 years seems likely to frighten candidates and should be reconsidered, perhaps consider teaching some undergraduate modules in English? The recruitment process relies mostly on external search committees, which might contribute to its (unbelievably) excessive duration; it is clear that a number of very highly qualified applicants have been lost (they have taken up other post) due to the time that the recruitment process takes. The permanent members of the Department should be involved as much as possible, and should at least have the opportunity to express their opinion, both on the profiles to be recruited and on the ranking of the applicants.

The research of the Eng Mech Dept ranges from a more basic (Low TRL) to a more applied, sometimes closer to product development (High TRL) it feels that it is mostly driven by current industrial needs, or that the future directions are highly influenced by the industrial partners. In this sense it is not surprising that hiring researcher, and faculty, is mostly driven by research contracts with the ‘today’ industrial needs in the focus. This condition does not encourage investing in ‘Low TRL’ research, and thus, or hiring faculty with a research activity centred in emerging areas or technologies, mainly because funding for Low TRL research is more scarce. A strategy to maintain a good balance, in terms of faculty, to address low TRL research in promising areas is encouraged. Certainly, the Thematic Research Projects involving faculty from different groups is a step in this direction. However, the short duration of the postdoc research contracts does not ensure that the ‘identified research topics’ are supported in a more permanent (or long term) basis. The natural renewal of the department faculty, and its long term planning, is a good tool to address these issues at the same time that the long-term department structure is consolidated in terms of research and teaching.

The department has an excellent record in hiring faculty with very high potential, as it is demonstrated by its 4 ERC grants. This is a remarkable achievement that must be not only valued but also used as a guide in future faculty hiring. Besides addressing well identified research areas, the hiring of junior faculty using, in a sensible way, the criteria of having an ERC potential is encouraged.

The current research areas in the Eng Mech Dept are active and important, with a national and international impact. Not only the maintenance of most of the ‘classical engineering’ is required but also a strategy to let ‘more obsolete and non-impacting’ research areas/topics fade away should be monitored. As resources are finite, the investment in new research directions (and eventually in new courses to be offered) can only be made either by expanding the funding or by replacement of current

activities. The hiring of faculty and research associates is an opportunity to implement a coherent strategy. By the same token, the promotion of junior faculty to more senior positions can be used as a tool to promote a departmental vision on research and teaching directions.

e. Infrastructure and facilities

The Odqvist Laboratory provides essential support to both research and teaching activities in the Department, and is made accessible, with fees, to external users. It has clear management and development structures and processes. Its technical support and development staff seem however limited in number considering the range of its equipment and activities. Although they do not complain about it, PhD students and post-docs have to train each other to use the facilities, so that there is a risk for the Department not to capitalize and maintain all its experimental competence, and potential danger for the users, unless an appropriate training to security rules is provided.

The lab has its own machining workshop, which is essential to develop new testing devices (more reactive and cost effective than subcontracting). It is structured in 4 parts: Lightweight structures lab, with quite classical testing devices, with a wide range of load capacities (some of which seem aging, and some oversized for current use), two multiaxial testing machines: axial–torsion and biaxial tension, thermal chambers, stereo DIC for strain field measurements, infrared thermography, Solids mechanics Lab (whose difference with the Lightweight Structures Lab is unclear), equipped for fracture mechanics, tension, creep and fatigue testing, including contact fatigue, Fluid Physics lab (subdivided in 4 parts, with wind tunnels, velocimetry, anemometry…), and Laboratory For sound & vibration research (anechoic and semi-anechoic rooms, reverberation room, shock & vibration room, flow acoustic test rig…). Space does not seem to be missing, but the large size of some of the equipment, embedded in the building itself makes transformations difficult.

The Odqvist lab has limited observation devices (only a metallographic optical microscope), while more advanced devices like SEM, TEM and AFM, necessary to relate the mechanical properties of materials to their microstructures and deformation and damage mechanisms, belong to the Hultgren Lab. Surprisingly, the latter does not seem so much used by the Department. In that respect, the creation of MUSCLE (Laboratory for Multi-Scale Experimental Mechanics) and acquisition of a nano-indentor, as well as the Centre for mechanics and materials design (MMD), are excellent initiatives for transdisciplinary research development and the renewal of research themes, especially in the fields of micro and nano-mechanics of materials.

A lab X ray tomograph might allow easier access to 3D observations than synchrotron external facilities, and be quite useful for several of the Department's research activities (poro-elasticity, ductile damage, and more generally, on all heterogeneous materials).

The Department has easy access to large computing and data storage facilities, as well as to local PC clusters. The technical support available at the department on this aspect is not clear.

There are good wind tunnel laboratories, but they suffer from the costing system as they are penalised by taking up lots of space.

The experimental laboratories of the department, with few exceptions, are assembled in a single location with a central management. This not only allows for a more efficient use of the space rented but also makes their running more efficient and cost-effective. On the other hand, the computational facilities are decentralized. Some of the computational power, supercomputers and highly-parallel computers, are shared with other KTH structures. Certainly, the Computational Fluid Dynamics make full use of these resources leading to impressive research outputs. However, there is another range of computational resources that are distributed geographically, being the concept of 'Computer

Laboratory' more abstract, but whose management and support may benefit from a structure with some relations to that managing the experimental labs.

3. Strategies and organisation

a. Goals for development 5–10 years ahead

The report remains rather vague on that point - Main goals (aims) are very woolly ("one of the most exciting places in the world!" and the objectives (how to meet the aims) don't specify what needs to be done.

The Department needs to work with high level objectives, break them down into actionable items, but at the same time keep a cross-functional KPI-matrix (Key performance Indicators) running. Given the individual strength of research teams and labs, the department should have an excellent basis to do this, but it has to be a conscious multi-divisions effort, with a longitudinal strategy and continuous self-evaluation.

b. Congruence with university-level goals

On nearly all points, the congruence with university level goals is very good. Concerning Multidisciplinary research and education however, little is mentioned in the self-assessment report on past or emerging collaborations with the other Schools, namely the ITM School (specially the Materials Science and Engineering and the Production Engineering Departments), the ABE School (specially the Civil and Architectural Engineering Dept) and the CBH School (specially the Biomedical Engineering and Health Systems and Fibre and Polymer Technology Departments) while there is a huge potential for synergies. Cross-Department collaborations nonetheless exist, for example through structures or centres like: SMARC (Underwater Robotics), ITRL (Integrated transport research lab), Express (production), MMD (Material mechanics and design), CCGEx (Competence centre for gas exchange), WWSC (Wallenberg Wood Science Centre). The best way to demonstrate the strength and quality of these collaborations in the future will be to monitor the co-publications and PhD joint-supervisions.

c. Leadership structure and collegial structure

The present structure seems rather informal, with some clear advantages, underlined in the self-assessment report, but also a few risks, like a lack of transparency in the decision processes, due to unofficial but strong influence of well-established full professors. As far as possible, heads of Department, Divisions, and maybe even of the largest Research Groups should be elected and renewed frequently enough, so as to give younger faculty regular opportunities to take responsibilities.

Every category, including the technical staff (whose work and skills was not highlighted in the report, and whose motivation should not be taken as granted, but acknowledged and maintained), as well as the postdocs (whose number was in sharp progression over the past years, but whose status and concerns are different from those of permanent faculty members) should be represented at the Department Council.

d. Strategies for achieving high quality

The report provides a few elements on that aspect, but further reflection is needed (for instance: which of the less vibrant research topics should be dropped in favour of emerging ones, given finite resources, and to avoid scattering, the suitable number and qualification of technical staff with respect to the

experimental developments, the equilibrium between temporary and permanent faculty positions, the most reasonable way to use bibliometric indicators and to share objectives concerning scientific productions…).

The policy regarding the number of required published or accepted publications before PhD defence should be re-discussed, giving more weight to quality criteria (journal rank or conference visibility, paper length, number of citations…), in order to reach a reasonable consensus within the whole Department. The resulting updated rules should be more clearly explained to the students, who did not themselves seem to think that the present rule was an absolute requirement.

Attention already seems to be paid to the employability of the PhD students. This should extend to the postdocs.

4. Interaction between research and teaching

a. Interaction between research and teaching at all three levels (B.Sc., M.Sc., Ph.D.) of education

The faculty seem serious about reflection on pedagogy and on improving their teaching. This is reflected in their willingness to publish on pedagogy in engineering. Particularly impressive that faculty members are also involved in initiatives outside the department around best practices in SDG in pedagogy.

The Department is strongly involved in several BSc, MSc and PhD programs and its Laboratories host a large number of training sessions and student's projects. However, the relation between the research activities and the teaching activities in the Laboratories do not seem clear. For instance, if a particular source of funding for a Laboratory vanishes, how will such Lab keep on supporting courses that use its 'services'?

Valuing innovation in teaching is supposed to be structured such a way that faculty get credit for their initiatives and have requirements in their promotion cases related with teaching innovation. However, it was not found evidence of any systematic and structured requirement (or metric) to promote such innovation. Certainly, the staff CV used for promotion has a significant part on teaching merits and reflections, and teachers are trained to develop their pedagogical portfolio on which they are evaluated. However, teaching innovation can be additionally promoted (and valued in the faculty CV) by: launching new courses reflecting the research activity (at any level, i.e., these can be BSc, MSc or PhD courses) or by upgrading substantial parts of existing courses; publication of pedagogical materials, with emphasis on books (monographies); promoting the use of 'industrial' case studies in class; Other activities that transfer the result of innovative research to the classroom.

PhD students advising seems to be loosely monitored, leading to inconsistent metrics and requirements for a successful defence of the Thesis. Fortunately, the quality of both Department faculty and students is such that general problems (if arising) can be solved almost in a non-formal manner. The need for at least 4 published/accepted papers (or 2 accepted/2 drafts & 1 reviewed Conference paper) is an expectation and not a requirement for a PhD (duration 4 years). Given the low publication rate per permanent staff it looks as either this requirement is not enforced or that Conference papers are given the same importance as journal papers published in top journals with a carefully monitored reviewing process (each PhD student should result in ~1 paper per year). In any case, the risk of favouring quantity rather than quality must be avoided. In the case of industrial PhDs, because of lengthy review processes by the company or the eventual non-disclosure agreements associated with the work, the requirements for publication must be properly adjusted.

Avoiding turbo-Professors must also be properly monitored to not only secure the quality of the research and advising but also to avoid the large scale problems resulting from unforeseen problems with the advisor. In the Department webpage it is reported that a professor seems to currently supervise 10 PhD students, which is the limit on the maximum number of students that can be supervised by a main supervisor. This number seems excessive for a good follow-up of the students' activities and quality supervising.

The balance between reporting and bureaucracy in the PhD student work tracking seems to have weaknesses that damage the credibility of the process. Several students expressed the feeling that the annual report was not useful and purely an exercise to be done because it is required. The impression that some/many advisors also do not take it seriously was also transmitted. There seemed to be a tension between the collegial, informal one on one interactions among faculty and students in the department, and bureaucratic structures that govern the way the system operates. Top-down bureaucratic processes seem to sometimes hinder action by making the system too rigid to adapt to new situations.

When the advisor-student relationship works well, students are happy. There is not a clear reporting mechanism or a safe space for addressing issues if they arise - students we asked had no idea what they would do if they or a friend was having an issue that couldn't be resolved by going directly to the advisor.

There appear to be relatively few avenues for students to develop professional skills beyond the immediate research project needs, as in most academic research programs, learning is primarily done through the advisor, by osmosis, and ad hoc/driven by the project needs. There is a need to create more systematic learning opportunities for students. The existing class about scientific writing is an excellent example that could be offered/required more uniformly for all the students. Skills such as writing, professional development, and career development can be systematically taught which would augment the efforts of individual advisors.

The sessions on research and teaching focused almost explicitly on the teaching of PhD students, but it also seemed that the faculty didn't get much credit for this. For the Masters the emphasis was mostly on the research project, and most of these were part of bigger research projects with supervision from postdocs or PhDs. Almost no mention (only one faculty mentioned this) of getting research into the undergraduate syllabus (how do you include up to date advances into these courses?).

A clear vision on what is the relation between research and teaching specifying what guides what and how seems to be missing in the Department strategy. In some Universities (research oriented Universities as opposed to teaching oriented Universities) the vision is that the duties of a Professor are to research (1st), to teach (2nd) and to support the University management and the societal development (3rd). However, the research has the goal to renew and upgrade teaching (1st) and to extend research to support societal (industrial, medical, legislative, etc.) needs. The statement of a vision that can frame a strategy for an interaction between research and teaching (at each individual level), being the one stated or any alternative, is advised.

5. Impact and engagement in society

a. Relevance, scale, and impact of the department's current engagement with society and industry

Research in the Department is very much in touch with societal needs (for safer, more durable and cleaner, more silent transport, for example) and industrial applications, but mostly from traditional sectors (automotive, rail, naval and aeronautics sectors), while more recent sectors, like electronics, seem less represented. The department systematically co-publish with leading industry companies to a

large extent and shows a wide variety of high relevance projects with problems identified by industry. The number of resulting patents also clearly indicates a very high level of industrial relevance and societal impact.

Furthermore, the fields of study are themselves a testament to the relevance of the departments work whether it being fatigue problems in the railway sector, or structural batteries for automotive and aerospace applications. The funding sources further reinforce this impression; many projects are funded by applied national funding agencies or the European Union with clear impact ambitions.

The department in addition engages in many information activities, start-ups and consultations. In the impact study examples the department also showcases the width of it's work, ranging from biomechanics to welding and industry 4.0.

Albeit the societal impact by the department, as a whole is impressive, the panel finds that there is an additional potential to be tapped into (see below). As an engineering department, it would be natural to tie its societal impact ambition to the challenge driven way of working identified by major external organizations.

b. Research dissemination beyond academia

The many applied projects have in themselves extensive and advanced dissemination forms beyond academic publication, such as conferences, white papers and different communication efforts (web, news etc.). In many of them it is simply required (e.g., H2020), others are apparently set up in this way by the department in the application phase. The interaction and collaboration with companies also provide dissemination into society – sharing, spreading and ensuring implementation of academic findings in society is indeed a powerful form of dissemination.

The impressive number of patents held by researchers also became evident during the interviews, something that both address high-level dissemination as well as impact issues.

As mentioned in the self-evaluation report, master student's projects performed within the Department and alumni contribute to research dissemination and knowledge transfer beyond academia, through alumni.

Yet another example is the open source format of many numerical tools developed at the Department.

A few examples were also given in the interviews of more high profile dissemination to the general public (Nobel days) but the impression was that more could be done with schools and local companies. Much of the dissemination seems to take place in already well established channels.

The panel furthermore notes that the web presence could be expanded and made more accessible for 3rd parties and more information for internal consultation when seeking opportunities for collaborative adventures.

c. Relation to sustainability and the United Nations' Sustainable Development Goals (SDGs)

The Department research was consistently and easily tied to the UN Sustainable Development Goals, and across the department, there are interfaces with several of the SDGs.

In the department presentation, Good Health and Well-Being, Quality Education, Affordable and Clean Energy, Sustainable Cities and Communities, Responsible Consumption and Production, and Climate Action were all directly addressed. Specific research areas addressed that interface with these goals are

in the areas of energy and sustainable vehicles, renewable materials, and climate. The use of the TRL levels to delineate more directly applicable work helps create more direct connections with the SDGs as well.

This emphasis on SDGs as part of what drives the Department's research is a powerful tool for excellence and appears to be genuine and not simply an "add-on" to position the different research groups toward these thematic goals.

Still, there is room for greater synergies and a greater shared strategic vision to be developed that is organized around the SDGs and other global challenges. The research themes and groups seem more to be re-aligned with the SDGs after their establishment, than springing from the underlying societal challenges identified indirectly by the SDGs. Although this is a reasonable historical order of things, the panel emphasizes the potential in truly back casting the societal sustainability challenges into departmental strategies.

The department structure could benefit from an alignment both in impression and actual form (too many labs, research groups, and "centra", confusions between former & new names, several web sites with different presentation styles, missing information). This could empower both a more easily navigated web interface as well as possibly internal cultural navigation as well.

However, the panel does not recommend (another) re-organization, merely a consolidation of the many sub-centra and groups. Maybe they can continue to exist simply by a clearer naming, maybe some could truly be consolidated.

Taking the societal challenges to heart and performing back casting processes in order to identify and highlight the most societally relevant research questions holds the potential to enable a strong chain between research excellence and societal impact.

Organization of conferences and workshops complemented by open days of the department and/or of its laboratories is a very efficient form of dissemination.

Public report of involvement of the department members in societal activities that involve departmental research and teaching activities, such as public interviews, participation in forums, involvement in National or International advisory groups, high impact consulting activities, is an effective dissemination tool, in social media in particular.

6. Recommendations for strengthening the department and its future potential

Consolidate the department organization in order to not only ensure critical mass and a rational assembly of research areas in all its divisions but also to better use synergies to reduce administrative and management work, thus allowing to enhance the steering of research.

The publication in peer-reviewed journals by the department faculty is relatively low, mainly due to the type of industry-driven research mostly carried in the department (and research centres in which it is involved) and because conferences are used as an alternative publication forms, often with the same importance as journals. A strategy to ensure that industrial projects lead to peer-reviewed journal publications, often replacing or complementing conference publication, together with the definition of a list of priority top-ranked journals in which to publish is recommended. We have notice that such list of journals already exists but remains to be disseminated properly.

Definition of Key Performing Indexes (KPI), which may include publications, citations, measures of scientific impact, funding, student training, etc., and a clear metric will be helpful not only to guide

junior faculty and postdoc in steering their careers but also provides tools for strategic decisions to the department.

The periodic organization of a major conference (eventually with an international focus) on collectively chosen and sufficiently wide themes, involving the different departmental units might help not only to consolidate the Department but also to identify internal synergies.

The department structure by application domains rather than by scientific problems might constitute an obstacle for internal collaboration if synergetic efforts are not identified. A restrictive branding of units or groups, as for example, contact mechanics, must better describe the area of application and not embrace other areas that also address scientific problems that use similar classifications encountered by diverse units. For instance, rolling contact mechanics in different vehicles, general contact mechanics between structural elements or between general shaped bodies, tribological aspects of machines are just examples of contact mechanics not addressed in the currently called contact mechanics group.

The diversification/renewal of industrial partners (will those outside the rail, automobile, space or naval domains identify the Department as a potential research partner?). Be careful not to miss synergies between the groups or overlap work. Need to do more across the overall sustainable transport portfolio rather than in individual groups.

Inadequate administrative support seems to be a genuine problem across the department. One recommendation is to poll the research groups, identify the administrative tasks which would be important to support research, find efficiencies (i.e., are there common tasks between groups which could be handled by one person?), and resource the unit. Since this is a new department, this is an important juncture to put in place adequate support. This is particularly important with regards to institutional efficiency and memory: if each researcher is individually figuring out what the correct way to do Task X is, that's a waste of time. If a researcher has unique administrative needs in their group and resolves it, and subsequently leaves- that is also lost knowledge. The use of a small part of the external funding (internal overhead) to support common administrative and technical managing tasks is a form to address the problem and decrease the researchers direct involvement in administrative and management activities.

The effort of ranking activities according to the TRL scale is commendable and very powerful in both internal and external interaction. It also specifically eases interaction with industry. However, there seemed to be potential for further internal synchronization of the detailed application of the scale; is TRL 9 the same thing as servicing other research teams (there was internal disagreement about this)? Does the industry agree? In order to fully utilize the potential of the TRL, it would be helpful for the department to discuss and make publicly available their own interpretation and examples of application.

Another area of important, but probably with an easy potential of improvement is to make the already existing PhD-student initiative systematic; provide support for the teaching assistants to make notes, pass on and share. Provide support for the students and postdocs to document and pass on instructions and routines for handling the equipment. Several PhD students informed us about collective initiatives like this, but there seemed to be no general approach.

Reports of eventual abuses at the Math and Engineering Mechanics departments are very low, or non-existent, when compared to the percentage of cases reported in other similar Universities in Sweden. Thus, a continuous monitoring of eventual unreported cases is advised.

7. Final remarks

The Department of Engineering Mechanics at KTH is one of the leading Departments in Europe and it is highly-ranked in the World. We commend them on their continued research excellence and encourage the University to support the Department to maintain its international prominence.

The Department results from a recent merger of 3 previous independent units, being its consolidation still underway. The able, enthusiastic and very active leadership of the Department ensures all conditions for a successful consolidation of the merger establishing strategies and mechanisms for its continuous development. All those involved in the Department, i.e., faculty, students and researchers, reported academically exciting and supportive atmosphere.

Most significant concerns we had could be traced to KTH-level policies, namely on administrative support and valuing the use of space (namely for Laboratories). These were echoed at the Board meeting by other Panels, suggesting a systematic concern.

Overall, we were able to access the material we needed, and commend the coordinators for their help in answering questions as they arose. We also thank the department for their enthusiasm and transparency, and compliment them on a highly successful academic enterprise.