RESEARCH REVIEW

DEPARTMENT OF MECHANICAL ENGINEERING

EINDHOVEN UNIVERSITY OF TECHNOLOGY

2013-2018

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Preface

This report contains the assessment by the external review committee of the Department of Mechanical Engineering at Eindhoven University of Technology (TU/e). On behalf of the committee, I would like to express my gratitude for the hospitality which we received, and for the open and constructive attitude in which interviews took place. We appreciate the time and effort spent on the self-assessment report and site visit by the management team and members of the Institute. The committee wishes to thank all interviewed persons for their willingness to share their insights and opinions with the assessment committee. In the many interviews, we were informed extensively and without hesitations or reluctance. We hope the Department can profit from this assessment.

Viggo Tvergaard, chair of the committee

1. Introduction

1.1 Terms of reference for the assessment

The quality assessment of research of the Department of Mechanical Engineering is carried out in the context of the assessment system as specified in the Standard Evaluation Protocol For Public Research Organisations by the Association of Universities in The Netherlands (VSNU), the Netherlands Organisation for Scientific Research (NWO), and the Royal Netherlands Academy of Arts and Sciences (KNAW).

The review committee was asked to assess the scientific quality and the relevance and utility to society of the research conducted by the Department in the reference period 2013-2018, as well as its strategic targets and the extent to which it is equipped to achieve them.

Accordingly, three main criteria are considered in the assessment: research quality, relevance to society, and viability. In addition, the assessment considers three further aspects: the PhD training programme, research integrity and diversity.

This report describes findings, conclusions and recommendations of this external assessment of the Department of Mechanical Engineering.

1.2 The review committee

The Board of Eindhoven University of Technology (TU/e) appointed the following members of the committee for the research review:

- Prof. Emer. Viggo Tvergaard (chair)
- Prof. Wolfgang Wall
- Prof. Gábor Stépán
- Prof. Andrew Alleyne
- Prof. Wolfgang Arlt
- Prof. Emer Sébastien Candel
- Prof. Beth Pruitt
- Dr. Erkan Asik

More detailed information about the members of the committee can be found in Appendix A. The Board of TU/e appointed dr. Annemarie Venemans of De Onderzoekerij as the committee secretary. All members of the committee signed a declaration and disclosure form to ensure that the committee members made their judgements without bias, personal preference or personal interest, and that the judgment was made without undue influence from the Department of Mechanical Engineering or stakeholders.

1.3 Procedures followed by the committee

Prior to the site visit, the committee received detailed documentation comprising: The Self-assessment report of the Department of Mechanical Engineering, including appendices, the Standard Evaluation Protocol (SEP) 2015-2021, a SWOT-analysis and curricula of the various programmes in the mechanical Engineering Department. In addition, the committee studied additional information that was provided during the site visit including a ranking exercise of research themes as well as an overview on diversity (male/female and Dutch/international) for master students, temporary staff (PhD/PD), and staff.

The committee proceeded according to the SEP. The assessment was based on the documentation provided by the institute and the interviews with the management, interviews with a selection of researchers and PhD students of the institute, and a lab tour. The site visit took place on December 5 and 6, 2019 (see Appendix B).

The committee discussed its assessment at its final session during the site visit. The members of the committee commented by email on the draft report. The draft version was then presented to the Institute

for factual corrections and comments. Subsequently, the text was finalised and presented to the Board of the TU/e.

The committee has struggled with the interpretation of the SEP-scores. First, the departmental scores are an overall evaluation of the department's research mission and performance as well as evaluations of the various research groups in the department. In the previous research reviews, research groups received individual scores. These cannot be directly and fairly compared to the score of the department given here. Second, based on the data provided, the committee is of the opinion that it is hardly possible to assess the quality of the department. Although the written documents provided for the seven sections and the laboratory visit were quite useful, to assess the quality of the department, more time should have been spent to examine scientific highlights and hear about future projects. However, the committee understands that this not the focus of the current SEP.

2. Organisation of the department

The department of Mechanical Engineering (ME) is one of the nine departments of Eindhoven University of Technology (TU/e). The department consists of three clusters. Each cluster consists of a number of sections, and each section consists of a number of (principal investigator) groups. Research clusters of the department aim to integrate fundamentals, design and manufacturing in a specific research area.

The three research clusters and seven sections of the department are:

- Computational and Experimental Mechanics, CEM (sections: Mechanics of Materials, Micro-systems, Polymer Technology)
- Dynamical Systems Design, DSD (sections: Control Systems Technology, Dynamics and Control)
- Thermo Fluids Engineering, TFE (sections: Energy Technology, Power & Flow)

The department is headed by a Departmental Board, consisting of the Dean, the Vice-Dean and the Managing Director. The educational directors and a student act as advisors and also attend the weekly Board meetings.

The committee understands the choice to divide the department in manageable sections. Its structure with clusters and sections appear to support maintenance of infrastructure and new faculty. In the opinion of the committee the names of most of the sections are well chosen. However, the sections 'Power and flow' and 'Energy technology' cover a large spectrum of topics that comprises heat transfer, porous media, combustion, fluid mechanics, multiphase flows, process engineering. The collection of research groups and topics undertaken seems less well integrated than other sections. It is suggested that a long-term strategic plan be developed for these sections to provide a clear and coordinated vision for the research efforts to be pursued within each.

There was clearly lively dialogue within sections and many examples of productive collaboration between them, including many organically formed individual interactions around projects, co-advising and co-authorship. However, the committee saw less evidence of sustained and systematic conversation across the sections that was enabled by organizational structure. If the department wishes to increase these interactions, it might use incentives such as funding for student support to start a new co-mentored project, etc.The committee valued the six weekly meetings of groups in the CEM cluster with groups of different departments such as Biophysics and Biomedical engineering in which PhD students present their work. This could serve as a role model for other clusters.

3. Assessment of the research

3.1 Quantitative assessment

The committee assessed the Department both quantitatively and qualitatively. For the quantitative assessment a four-point scale is used, according to the standard evaluation protocol 2015-2021. The explanation of the criteria underlying the scores can be found in appendix D. The qualitative assessment of the Department can be found in the next sections.

According to the SEP scoring system, the committee has awarded the following scores to the Department:

Research quality:	1
Relevance to society:	1
Viability:	2

3.2 Research quality

The committee came to the conclusion that, when translating its opinion into the categories of the SEP 2015-2021, the overall quality of the research falling within its remit qualifies as 1 (excellent). The committee's opinion is based on the following considerations.

As a starting point, in terms of the type of research it produces, the department is extremely successful. Members of the department are producing world-class research on a wide range of relevant research topics. The research is disseminated largely in terms of academic publications, which are published in very reputable, often very prestigious, venues in the field of engineering and science e.g. IEEE Transactions on Control Systems Technology, Journal of Sound and Vibration, IEEE Transactions on Automatic Control, IEEE Transactions on Vehicular Technology, Progress in Energy and Combustion Science, Combustion and Flame, Physics of fluids, International Journal for Numerical Methods in Engineering, ... The fact that a large number of publications appear in peer-reviewed top journals indicates the originality, significance, and international reputation of the researchers.

The quantitative data provided in the self-assessment report are not very detailed. However, they give some indication of the productivity of the researchers during the reference period. The data show that ME on average produced 3.8 journal publications per research staff FTE per year in 2013, which has grown to 5.2 journal publications in 2018. The committee has also based its evaluation on its prior knowledge of the scientific contributions of the different research groups. According to the committee, this rate is in line with a healthy rate of publication. The current rate of over 5 per staff FTE is quite good and the fact that the rate has grown over the past several years to reach this level is a positive sign.

The number of documented patents is low, which might be critical in certain evaluation protocols, and also could be related to the otherwise excellent and large number of spin-offs.

The Committee took note of the department's reported research highlights. It has, for example, won substantial competitive grants such as two Simon Stevin Meester Awards, one VICI grant, four VIDI grants, eight VENI grants, two ERC advanced grants and four ERC starting grants. The international academic reputation of the department is also demonstrated in the awards and prizes various academic staff members have received for their research achievements. One group has permanent visiting arrangements with strong researchers from Cambridge University. In addition, researchers have been invited to deliver keynote lectures. Some staff members are part of advisory boards, editorial boards of journals, or external academic institutions and committees, one is the current President of Euromech. In addition, to the senior group members being well recognized, many of the younger faculty members are also doing well.

Some of the groups are among the world leaders in nonlinear dynamics and control, and in mechanics of materials, and the relatively young research field of microsystems is growing rapidly. There is a high potential for the research on energy and related fields due to its relevance for actual political decisions in

The Netherlands. The visibility of the research in control systems is especially good; the field attracts many doctoral students.

The physical infrastructure for conducting research is comparable to top level research programmes throughout the world. All equipment the committee saw during the lab tour was state of the art and many of the in-house characterization testing capabilities were both novel and scientifically rich.

Part of the mission statement of the department is to realize an education and research programme with a balanced combination of fundamental and application aspects, thereby aiming at providing industry with scientifically educated and application-driven engineers who are optimally equipped to address future challenges.

The committee noted that ME performs both basic research projects financed with long-term research projects from national and international funds like NWO and ERC, in addition to more applied research in collaboration with local industry. There are also good examples of PhDs financed by the industry, where the research topics take into account the special interests of the industry, but also gives the possibility to work on a given project for several years in a consistent way. The committee believes that the balance of attention seems to be more towards the application side of mechanical engineering. Given its embedding in a university that is quite application minded, more weight on applied research is understandable. However, the committee felt that it would be advisable to strategically augment the department's overall research portfolio with an increased basic research effort. This diverse portfolio would undertake more projects targeting a technical impact in the time period of five to fifteen years after completion thereby adding to the scientific and technical academic community.

The department provides a good environment for the promotion of interdisciplinary research. The committee has seen good examples of research collaborations. However, it believes that the research is still too narrowly organised in traditional disciplinary concentrations. The committee is of the opinion that ME needs to look for more and better ways of promoting and facilitating collaboration between sections within the department and with scholars from disciplines beyond those covered by mechanical engineering.

One potential way of improving international cooperation is by a more efficient use of the sabbatical system. The system exists, but it is not exploited properly, partly due to the high teaching load and partly due to the limited mobility of the senior staff. This should be addressed in the future, for instance by organizing the substitution for teaching with temporarily hired staff, or by encouraging “staybatical” when the professors can have one or two semesters without teaching and can concentrate on research, publications or project proposals.

3.3 Societal relevance

The committee came to the conclusion that, when translating its opinion into the categories of the SEP 2015-2021, the research of the department generally qualifies as excellent (1) as far as relevance to society is concerned.

Training of engineers and more specifically mechanical engineers is of importance for society. Mechanical engineering is needed to solve problems of energy, mobility, machinery, construction, materials environment etc. Mechanical engineering is pervasive and the mechanical engineer has most often been the technology integrator playing a major role in making things happen. Thus, training high-level innovative mechanical engineers with a strong fundamental basis is of considerable relevance to society and in this respect this department plays an essential role through education, training and research.

Relevance appears as a central item in the definition of research directions of the mechanical engineering department. Most research projects originate or are driven by industrial or societal needs. This is adequate for engineering and the dialog with industry is fruitful and beneficial to all parties. Relevance is manifested in the strong ties that the department has developed with industry. The dialog with industry is well established with some excellent initiatives like the “Impuls” programme which offers a clear incentive for long-term industry-academic partnership by matching industry supported PhD work with department support. The presence of high-tech industry in the area and the strong connections that

have been made between the department and the surrounding enterprises and the Brainport Eindhoven ecosystem are certainly an asset to both parties and to a healthy economy that is essential for society.

Research carried out in the department and the various actions taken to provide professional skills to the doctoral students as well as the environment provided by the innovation center creates the culture and atmosphere needed to develop spin-offs. The department and the university encourage the development of start-ups and this is highly relevant for the creation of new companies, new jobs and employment.

The department has established a remarkable dialog and partnership with industry and enterprises, it responds to their current needs and is also successfully engaged in the development of spin-offs. This should be pursued and consolidated but the department should also try to put more emphasis in getting ahead of industry in addressing some of the grand challenges that are facing society in the areas of energy, mobility, water, environment and health. In this respect it is important to keep a good balance between fundamental and more applied research.

3.4 Viability

Whilst the previous two sections contained an assessment of the performance of ME during the reference period, this section is more forward-looking. The committee came to the conclusion that, when translating its opinion into the categories of the SEP 2015-2021, ME ranked as very good (2) for viability. The committee's opinion is based on the following considerations.

As noted above, steady signs of quality improvement could be observed across the review period; ME has had very marked success in grant winning, it is securing added societal partnerships and it is fostering synergy and dialogue internally. The fact that the department board is established from strong academic personalities and that it is well-rehearsed is especially appreciated. Also, the interaction between the department board and the department council, the individual sections and groups as well as to the Executive Board of the University seems very healthy. It is appreciated that the creation of clusters has been done in a slim way, i.e. they are used where helpful but the department didn't fall into the trap to create an additional administrative level along with it.

A strength of the department is the internal promotion of young internal talents that are then subsequently incorporated into the faculty. However, doing this too excessively might be risky on the long term; this might be particularly relevant for groups that have been very influential in a field and have done very well for a long time. It can lead to a tunnel vision, create stagnation and lead to blind spots and missed opportunities – even when groups are well embedded in the international community as it is the case for many groups in the department. For long term viability the panel finds it important to ensure a continuous healthy inflow of faculty with diverse ideas from the outside. The committee is happy to see the latest developments of the department in this respect

The department provides robust and stable research support to its staff through excellent physical laboratory infrastructure as well as novel financial infrastructure tools. One example of the novel financial infrastructure is the policy of not applying overhead to external research grants obtained by the faculty/staff. This gives the research leaders a great deal of flexibility to maximize their resources in pursuit of new ideas. Another novel financial aspect is the ability to accumulate resources from research grants over multiple years to invest in larger pieces of equipment or other specialized research infrastructure. These investments provide a great deal of robustness to the research enterprise because individual equipment or shared infrastructure can be leveraged across multiple research efforts over multiple years. It is an example of a stable research base from which to launch future investigations. The joint labs also are very healthy with respect to cooperation within and across departments and with industry. The department should maintain these policies.

The department is in the midst of planning and executing a building renovation. The future facilities will have expanded research space, which will be critical to meet the needs of an expanded faculty size. It will be imperative for the department, and the university, to carefully plan for the transition between the current building and the new building. Disruption of research across the department should be minimized; if research is to be disrupted, the duration of disruption should be kept as low as possible. This will be critical to department plans for adding new faculty since it will be hard to attract senior faculty during an

uncertain disruption and any assistant professors that are added will be slowed in their career start if the facilities are unavailable for any length of time.

As expressed to the external review committee, the current teaching load at TU/e ME is higher than it was six years ago. The use of Project Based Learning, while very effective as a pedagogical approach, does consume departmental resources; most notably faculty/staff time. The opportunity cost of increased attention to teaching is that there is greater stress on the staff and/or there is relatively less attention paid to the research enterprise. The impression of the committee is that there was an evolution in the teaching load increase. It is recommended that the departmental leadership regularly examine the total resources available and map out the application of those resources in comparison with the strategic goals. There is a 40/40/20 split on research/teaching/service proposed for faculty time. Is there a similar breakdown from a departmental level on overall faculty/staff resources? If so, does the current departmental allocation match that goal and, if not, what steps could be taken to align the current process with the envisioned strategy.

The department has spent a great amount of time and effort to improve the diversity of the TU/e ME by changing the demographic makeup of the department (see also 3.7). Many previous international studies have demonstrated that a diverse organization is most effective when it is part of an open and inclusive culture. An inclusive culture is one that promotes and encourages presentation of a broad set of ideas; where individual voices have an opportunity to be heard. This maintains and advances the wide variety of strong intellectual concepts of interest to the ME department. The current departmental leadership has paid less attention to the creation of an inclusive culture than to the changing of the demographic makeup. If this were remedied it would maximize the intellectual benefits associated with the envisioned faculty growth.

The future of the department depends very much on the quality of the faculty that is hired. It Is important that the department makes sure to hire only highly qualified candidates for new positions that become available. This is a condition for being able to maintain the position as a strong research university on a high international level.

3.5 PhD programme

In the period 2010 – 2014 a total of 145 PhD students enrolled in ME. Of 145 started projects, 10% of the projects were completed in 4 years, 74% of the projects were completed in 5 years, 83% of the projects were completed in 6 years and 87% of the projects were completed in 7 years. Another 4% of the projects were still pending by the end of 2019 or failed (10%) (see also Appendix C, table 4).

The department has currently about 170 PhD students. On the average this means that each faculty member is advisor of 3-4 PhD students. The PhD students are mentored by two or more supervisors. In many cases there is a co-supervisor from the industry. This strengthens the connection between the scientific output and industrial applicability. At their start of the PhD programme, a new PhD student is mentored by a more senior PhD student (a buddy). The committee applauds this idea.

The committee interviewed current PhD students in various stages of development of their doctoral research about their supervision, research facilities and possible constraints of their research. The PhD students the panel spoke with were enthusiastic about working in the ME department. They especially enjoy the open atmosphere.

The university offers a set of personal development (PROOF) courses. The students the committee spoke with during the site visit were confident with the courses they could attend. During their study, the PhD students supervise MSc and BSc projects which improves their supervision capabilities and also broadens their knowledge in different aspects of mechanical engineering.

Disciplinary courses are primarily offered through Research Schools. The department participates in six Research Schools. The TU/e is commissioner of one of these Schools, namely Engineering Mechanics. The mission of the Netherlands Research School on Engineering Mechanics (EM) is to strengthen academic research and education in the field of engineering mechanics in The Netherlands. Thematically, EM covers modelling, analysis and optimization of the static and dynamic behaviour of materials, products and mechanical processes.

The committee is of the opinion that EM amply fulfils its mission and goals. The number of staff and students give clear evidence that it has the size to constitute an academic community (266.5 FTE). The committee was impressed by the activities enabling students to learn from some of the best researchers outside their own universities. EM offers a broad range of classes, seminars and workshops that are the core of engineering mechanics and play an important role in the training of PhD students. An individual university could not provide this support in a comparable way on its own. In addition, the committee believes that EM provides a great opportunity for the networking between lecturers and PhD candidates from all over the Netherlands through the interaction of the various faculty members, who are involved as lecturers and students in this school.

Partly due to administrative reasons, the success rate of PhD students finishing within four years is low. However, most of the PhD's graduate within five years. The procedure between handing in the finished manuscript and the actual dissertation defense takes 3-4 months. Therefore, PhD candidates working for four years on their research, fall within the five-year category.

The department monitors the quality of the PhD programme by doing exit interviews with PhD students and investigating the reasons for drop-out. The committee recommends ME conducts an annual survey on the work climate of their PhD students in an anonymous way and utilizing this information to improve processes and procedures that would continuously enhance the PhD environment.

3.6 Research integrity

ME conforms to the TU/e policy with respect to research integrity issues. It builds on more detailed and comprehensive documents that deal with these matters, such as The Netherlands Code of Conduct for Academic Practice (VSNU) and to the TU/e Code of Conduct. These documents formulate ideals, responsibilities and rights that should be taken as guidelines for everyone who is part of the TU/e. In addition, at the start of their contract, new faculty members, PhD students, PDEng trainees, MSc students and guests are required to sign the TU/e Code of Conduct, which is attached to the employment/guest contract.

The Committee is pleased with the processes in place for ensuring research integrity, and that the faculty is well aware of the ethical dimensions of scholarship. The department seems highly professional in its programming, policies on data storage, attitudes and culture of openness.

3.7 Diversity

Gender diversity is low at faculty level relative to 50% in society, while higher than the diversity of student body at all levels. For a number of reasons, increasing faculty gender diversity has been frequently correlated with concomitant increases in student diversity. To maintain their international reputation, TU/e Mechanical Engineering has committed to this undertaking with a desire to reflect the composition of international society, but certainly at least Dutch society. With increased diversity, TU/e ME expects to gain the benefits of a diversity of backgrounds, cultures, genders and opinions in team problem solving to reach better solutions, more ideas and better outcomes from mixed teams – as has been reflected from many prior studies of the effectiveness of engineering teams. To achieve this, TU/e has adopted an approach of opening faculty positions with priority to female candidates only for six months, placing two female faculty on all search committees and interviewing one female for every male. While this will certainly increase the visibility of female candidates in the pool, the committee was concerned this may have unintended consequences. For example, some women who might have applied, may choose not to apply into this process because they do not want to be "hired because they are a woman", if there are not 1:1 ratio of female/male excellent candidates, time will be wasted on extra interviews. By requiring two of the few women in the department to be involved in every interview and search, the department places extraordinary burden on its existing female faculty.

Increasing awareness of diversity and gender issues within the department was described as residing with the female committee members who are trained in gender bias or with the WISE organization who could point out what interventions or changes are needed. The committee would refer the department to the wealth of literature and best practices at other peer institutions and encourage that all faculty be

exposed to them to create a culture of advocacy for diversity and recognition of implicit bias. By making all faculty aware and encouraging advocacy, male faculty can also act as advocates or intervene when they witness inappropriate comments or stereotyping of diverse students and staff. The ability to welcome and develop a more diverse student body will be greatly supported by changes to the culture and environment, e.g., by identifying and celebrating the success and contributions of ME female role models from industry or academic researchers from outside TU/e. Much research has shown that women and minority engineering students are more attracted to projects, programmes and applications with social impact and societal relevance, and TU/e has many such research projects and spin-out companies that provide excellent examples.

The department participates in children's day and this was deemed popular and successful. However, increasing interest in mechanical engineering can be supported by using a multi-faceted approach to encourage inclusion. For example, young people in secondary school are much closer in age when compared with faculty. Creating programmes and opportunities for the students (BS, MS, and PhD) to mentor or interact with secondary school students can also provide a full-circle approach to increasing diversity in the pipeline. This is sometimes termed 'Intergenerational mentoring.' While staff can be effective advocates and promoters of the department, you leverage their involvement in the full chain by encouraging and creating opportunities to leverage the large number of students in recruiting and outreach (Staff -> PhD -> MS->BS-> secondary school).

The committee heard only positive comments from students about the inclusion and on-boarding process for international students and Dutch students alike. The strong mentoring and advising programmes and "buddy" programmes are an asset in making students feel welcomed and included. The focus on project based learning and hands-on team work also help integrate all students and get to know one another. The committee did hear that the students would also like to see more intentional mixing of the Dutch and international students and while they felt this was actively promoted socially by the student organizations, they wished for more at the department level. The department might consider using rational team design approaches (there are many online team-maker tools, e.g. CATME, etc.) to assemble teams for the first-year projects which have been shown to promote more effective and functional teams and also provide online assessments to catch students who feel disconnected earlier in the process.

4. Summary and recommendations

The review committee was asked to assess the scientific quality and the relevance and utility to society of the research conducted by the Department in the reference period 2013-2018, as well as its strategic targets and the extent to which it is equipped to achieve them.

Its overall impression is of an excellent Institute in which there is a strong sense of professionalism, impressive commitment and very high levels of performance in terms of publications in clearly identified, leading journals. The physical infrastructure for conducting this research is comparable to top level research programmes throughout the world.

The definition of research directions of the mechanical engineering department. as well as the active participation in training programmes and especially the interaction with various stakeholders in the many externally funded research projects in the institute yield clear evidence that the scientific work of the institute also has a very high societal relevance and impact.

The department is very well equipped for the future. In the opinion of the committee, steady signs of quality improvement could be observed across the review period; ME has had very marked success in grant winning, it is securing added societal partnerships and it is fostering synergy and dialogue internally. The fact that the department board is established from strong academic personalities and that it is well-rehearsed is especially appreciated. Future challenges include improving the time for research, hiring highly qualified candidates for new positions, attracting female researchers and more collaboration within the Department and beyond.

With regard to the PhD programme there is a good supervising structure both intellectually and procedurally. In terms of education, the university offers a set of personal development (PROOF) courses. Disciplinary courses are primarily offered through Research Schools of which the Research School, Engineering Mechanics, is commissioned by the department. The committee is of the opinion that EM amply fulfils its mission and goals. It offers a broad range of unique classes, seminars and workshops that are the core of engineering mechanics and play an important role in the training of PhD students.

The committee is satisfied with the processes in place for ensuring research integrity.

Gender diversity is low at faculty level relative to 50% in society, while higher than the diversity of student body at all levels. The ability to welcome and develop a more diverse student body will be greatly supported by continuous improvement to the culture and environment, e.g., by identifying and celebrating the success and contributions of ME female role models from industry or academic researchers from outside TU/e.

The committee invites the department to consider the following recommendations.

- Keep a good balance between fundamental and applied research;
- Develop more systematic cooperation, collaboration and interaction between the different sections;
- Put more emphasis in getting ahead of industry in addressing some of the grand challenges that are facing society in the areas of energy, mobility, water, environment and health;
- Improve international cooperation further by a more efficient use of the existing sabbatical system;
- Examine best practices for creation and maintenance of an inclusive environment;
- Maintain high quality space infrastructure commensurate with growth in students and staff. This is for both the near-term transition and with the future state of the new building;
- Consider some flexibility in the implementation of the diversity hiring targets and how to manage this approach to minimize unintended consequences;

Appendix A – Curriculum Vitae

Viggo Tvergaard is a Professor Emer. of Solid Mechanics at the Technical University of Denmark. He got his Ph.D. in 1971 from the Technical University of Denmark, and his dr. techn. degree in 1978. His primary research interests are instabilities of structures and solids, the mechanics of materials, fracture mechanics, damage mechanics, and micromechanics. Since 1995 he is the Editor-in-Chief of the European Journal of Mechanics A/Solids. He is a foreign member of Royal Netherlands Academy of Arts and Sciences, and of the US National Academy of Engineering, and is an honorary member of ESIS, Eur. Struct. Integrity Soc. He obtained an Honorary Doctor Degree from the Royal Institute of Technology, Stockholm, Sweden, 1993. He received the 1998 Koiter Medal of ASME, the 2009 Euromech Solid Mechanics Prize, and the 2017 Timoshenko Medal of ASME. Tvergaard was President of IUTAM from 2012 to 2016, and now he is Vice-President of IUTAM.

Wolfgang Wall is full Professor and founding director of the Institute for Computational Mechanics at TU Munich. Among others he acted as founding director of the Munich School of Engineering and is co-founder of the companies AdCo EngineeringGW and Ebenbuild. He received several esteemed awards and serves on a large number of prestigious boards. He currently also serves as Rector of CISM in Udine (Italy) and is member of the Austrian Academy of Sciences as well as of the Bavarian Academy of Sciences and Humanities. His research interests can be described as “application motivated fundamental research” in a broad range of areas in computational mechanics, with applications spanning all fields of engineering and the applied sciences, with a special focus on multifield, multiscale and bioengineering problems.

Gábor Stépán is a professor of Applied Mechanics, member of the Hungarian Academy of Sciences and the Academy of Europe, ERC Advanced Grant holder, recipient of the ASME Thomas Caughey Dynamics Award, former dean of the Faculty of Mechanical Engineering at Budapest University of Technology and Economics. His research fields include delayed dynamical systems, stability theory, and nonlinear vibrations. He is current or former member of the editorial boards: Nonlinear Dynamics, Philosophical Transactions of the Royal Society, Mechanism and Machine Theory. He serves as an elected member of the EuroMech Council and the ECCC of IUTAM.

Andrew Alleyne received a B.S. Degree from Princeton in 1989 and his M.S. and Ph.D. degrees in 1992 and 1994, respectively, from U.C. Berkeley. He joined the University of Illinois, Urbana-Champaign in 1994 where he holds the Ralph & Catherine Fisher Professorship and is the Director of the NSF ERC on Power Optimization for Electro Thermal Systems (POETS). He is appointed in Mechanical Science & Engineering and Electrical & Computer Engineering. A Fulbright fellow, he has held visiting appointments at TU Delft, University of Colorado, Johannes Kepler University, and ETHZ. He is a Fellow of ASME, IEEE, and AAAS and is the recipient of the Control Engineering Practice Award from the American Automatic Control Council, and the Advocating Women in Engineering award from the Society of Women Engineers. His research interests are a mix of theory and implementation with a broad application focus.

Wolfgang Arlt was a full professor for separation science and thermodynamics up to his pension In 3/2018. He has an Industrial background with Bayer company during 12 years working as a chemical engineer. He entered TU Berlin In 1992, received a job offer from TU Dresden and finally followed a job offer by Erlangen University In 2004. He headed the German working party on separation for 6 years. He founded the Energy Campus Nuremberg and became Its first director, a joint research unit for energy with approx. 150 scientists. Wolfgang is inventor of ca. 70 patents and author of 200 scientific journal contributions. He was in the editorial board of German "Chemie Ingenieur Technik" journal. His efforts were honored by the Emil-Kirschbaum-medal and the nomination for the future prize of the federal German president In 2018. His present efforts are dedicated to avoid the progress of the climate change.

Sébastien Candel is a University professor emeritus at CentraleSupélec, University Paris-Saclay. He obtained an engineering degree from Ecole Centrale Paris, a PhD from the California Institute of Technology and a Science Doctorate from UPMC (University of Paris 6). His research in the domains of combustion and aeroacoustics has applications in energy and in aerospace propulsion. Among many distinctions, Sébastien Candel has been the recipient of the silver medal of CNRS, the Marcel Dassault Grand Prize of the French Academy of sciences, the Silver and Gold medals both from the *Combustion Institute*. Sebastien Candel is currently chairing the scientific council of EDF. He is a member of the French

Academy of sciences and was its vice president and its president (from 2015 to 2018). He is a founding member of the French Academy of technologies and a foreign member of the *National Academy of Engineering* of the United States.

Beth Pruitt is a Professor of Mechanical Engineering and Biomolecular Science and Engineering, she moved to the University of California Santa Barbara in 2018 to help build a new Bioengineering program and department. She was on the faculty at Stanford University from 2003-2018 in Mechanical Engineering and Bioengineering, where she led the Stanford Microsystems Lab focused on small-scale metrologies for interdisciplinary micro-mechanics applications such as mechanobiology, biomechanics and sensing.

Erkan Asik has completed his PhD study in the faculty of Engineering Technology at University of Twente in November 2019 on damage in dual phase steels, He is working in the field of mechanical engineering and materials science towards understanding material/structural behaviour and failure under mechanical loading. He has received his BSc. from the Department of Metallurgical and Materials Engineering at Middle East Technical University, Turkey and his MSc degree from the same department on production and characterization of Titanium foams.

Appendix B - Programme of the site visit

Wednesday December 4

Time	Part	Collocutors
15.00 – 17.00	Site visit preparation	committee
18.00 – 20.00	Dinner with Rector and Department Board (DB)	Baaijens, prof.dr.ir. F.P.T. (Frank), CvB (Executive Board) Goey, prof.dr. L.P.H. de (Philip), Department Board, Dean
20.00 – 22.00	committee time	committee

Thursday December 5

Time	Part	Collocutors
09.00 - 10.00	Department Board (DB)	Goey, prof.dr. L.P.H. de (Philip), Department Board, Dean Geers, prof.dr.ir. M.G.D. (Marc), Department Board
10.15 – 10.45	Department Council (FR)	Frijns, dr.ir. A.J.H. (Arjan), Energy Technology, Council chair Govaert, prof.dr.ir. L.E. (Leon), Polymer Technology Hasker, ing. J. (Jan), Power & Flow Verhaegh (Bart), student, Council Vice Chair Van der Beuken (Loes), student
11.00 – 11.15	Committee break	committee
11.15 – 11.30	Mechanical Engineering Research School	Van Brummelen, prof.dr.ir. E.H. (Harald), scientific director
11.30 – 12.00	Representatives PhD's	Huang, ir. C. (Chih-Chia), Power & Flow Kottapalli, S. (Shravan), Energy Technology Shah, V. (Varun), Mechanics of Materials Gomez, C.F. (Camila), Power & Flow Vermeij, ir. T. (Tijmen), Mechanics of Materials
12.00 -12.30	Representatives Young scientific staff and Postdocs	Guerreiro Tomé Antunes, dr. D.J. (Duarte), Control Systems Technology Breemen, dr.ir. L.C.A. van (Lambert), Polymer Technology Islam, dr. T. Ul (Tanveer), Microsystems Rijvers, L.P.M. (Len), Power & Flow
12.30 - 13.30	Lunch	committee
13.30 - 15.00	Lab tour	committee
15.00 – 15.30	Representatives 'Computational and Experimental Mechanics' research cluster	Anderson, prof.dr.ir. P.D. (Patrick, Polymer Technology Geers, prof.dr.ir. M.G.D. (Marc), Mechanics of Materials Hoefnagels, dr.ir. J.P.M. (Johan), Mechanics of Materials Luttge, dr. R. (Regina), Microsystems Toonder, prof.dr.ir. J.M.J. den (Jaap), Microsystems
15.45 – 16.15	Representatives 'Thermo Fluids Engineering' research cluster	Deen, prof.dr.ir. N.G. (Niels), Power & Flow Gaastra - Nedea, dr. S.V. MSc (Silvia), Energy Technology Smeulders, prof.dr.ir. D.M.J. (David) , Energy Technology Tang, dr. Y. (Yali), Power & Flow
16.30 - 1700	Representatives 'Dynamical Systems Design' research cluster	Heemels, prof.dr.ir. W.P.M.H. (Maurice), Control Systems Technology Lopez Arteaga, prof.dr.ir. I. (Ines), Dynamics and Control

		Nijmeijer, prof.dr. H. (Henk), Dynamics and Control Reniers, dr.ir. M.A. (Michel), Control Systems Technology Saccon, dr. A. (Alessandro), Dynamics and Control
18.00	Dinner and evaluation	committee

Friday December 6

Time	Part	Colluctors
09.00 - 10.00	Department Board	Goey, prof.dr. L.P.H. de (Philip), Department Board, Dean Geers, prof.dr.ir. M.G.D. (Marc), Department Board
10.00 – 12.00	Committee meeting	committee
12.00 - 13.00	Lunch	committee
13.30 - 14.00	Reporting preliminary findings to Rector and Department Board	Baaijens, prof.dr.ir. F.P.T. (Frank), CvB (Executive Board) Goey, prof.dr. L.P.H. de (Philip), Department Board, Dean
14.00 – 14.30	Reporting preliminary findings to Department	plenary

Appendix C - Tables

Table 1 Number of staff in PYE*

	2013	2014	2015	2016	2017	2018
Scientific staff	64.0	61.5	57.6	58.8	57.0	56.9
Post-docs	21.6	23.8	18.6	22.8	26.3	19.2
PhD students	151.3	149.1	142.4	163.4	160.8	165.9
Total research staff	236.9	234.4	218.6	245.0	244.1	242.0
Support staff	58.1	57.2	52.0	48.7	44.6	40.5
Total	**295.0**	**291.6**	**270.6**	**293.7**	**288.7**	**282.5**

* Unit pye, short for person-year-equivalent, is time-averaged fte,

Table 2 Main categories of research output

	2013	2014	2015	2016	2017	2018
Refereed articles	240	247	227	278	312	296
Refereed conference papers	172	181	159	145	136	104
Book chapters	12	8	16	10	12	17
PhD theses	20	42	31	28	27	28
Total	444	478	433	461	487	445

Table 3 Funding

	2013	2014	2015	2016	2017	2018
Direct funding[1]	0.0	0.1	0.4	0.9	1.3	1.3
Research grants	4.3	4.9	4.2	3.9	4.1	4.4
Contract research	5.9	5.8	6.3	6.5	6.4	6.2
Total funding	**10.2**	**10.8**	**11.0**	**11.3**	**11.8**	**12.0**
Personnel costs	7.3	7.2	6.9	7.6	7.7	7.7
Other costs	2.9	3.6	4.1	3.7	4.1	4.3
Total expenditure	**10.2**	**10.8**	**11.0**	**11.3**	**11.8**	**12.0**

[1] direct funding by university, for research. This is not the direct funding for departmental level

Table 4 PhD candidates

Enrollment				Success rates					
Starting year				Graduated in year 4 or earlier	Graduated in year 5 or earlier	Graduated in year 6 or earlier	Graduated in year 7 or earlier	Not yet finished	Discontinued
	M	F	M+F	#	#	#	#	#	#
2010	30	4	34	5	22	1	0	0	6
2011	33	5	38	4	25	4	2	0	3
2012	22	3	25	3	17	1	1	0	3
2013	32	2	34	1	23	4	2	3	1
2014	28	4	32	4	17	5	n.a	3	3
Total	145	18	163	17	104	15	5	6	16
	89%	11%	100%	10%	74%	83%	87%	4%	10%

Appendix D – Meaning of the scores

Category	Meaning	Research quality	Relevance to society	Viability
1	World leading/ excellent	The research unit has been shown to be one of the few most influential research groups in the world in its particular field	The research unit makes an outstanding contribution to society	The research unit is excellently equipped for the future
2	Very good	The research unit conducts very good. internationally recognised research	The research unit makes a very good contribution to society	The research unit is very well equipped for the future
3	Good	The research unit conducts good research	The research unit makes a good contribution to society	The research unit makes responsible strategic decisions and is therefore well equipped for the future
4	Unsatisfactory	The research unit does not achieve satisfactory results in its field	The research unit does not make a satisfactory contribution to society	The research unit is not adequately equipped for the future