

RESEARCH REVIEW

CIVIL ENGINEERING

DELFT UNIVERSITY OF TECHNOLOGY



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REPORT ON THE RESEARCH REVIEW OF CIVIL ENGINEERING OF DELFT UNIVERSITY OF TECHNOLOGY

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1. FOREWORD BY COMMITTEE CHAIR

Reviewing departments and faculties can sometimes be arduous. Not so in this case. My fellow committee members and I are all very happy to have served on this review committee for the Faculty of Civil Engineering at Delft. We enjoyed reading the self-assessment reports, and especially appreciated the site visit during which we held productive and engaging conversations with the leadership and faculty members, students and postdocs. We would like to thank the Dean, department chairs as well as the supporting staff for their hospitality and the impeccable organization of the site visit and preparatory phase of the review. We are also greatly indebted to Meg van Bogaert, who superbly assisted us during the whole review process. It is safe to say that we all learned a lot from the visit and left Delft with a very positive impression of the Faculty, which you will see reflected in the overall scores assigned to the departments and the Faculty and the written report presented here.

Marc Parlange (Monash), Joannes Westerink (Notre Dame), Gerhard Mueller (TU Munich), William Lam (Hong Kong Polytechnic), Karin Sluis (Witteveen + Bos), and I, Margot Gerritsen (Stanford), have worked in research areas related to the four departments we reviewed for a combined total number of years that is much higher than we would like to openly admit. We were therefore already familiar with much of the research done at Civil Engineering in Delft. Yet, we were pleasantly surprised in many ways. On a personal note, and I have heard from several of my colleagues they felt similarly, I was especially struck by the collegial and supportive environment in the Faculty. I have always seen Civil Engineering "Civiel" as an open and inviting unit at Delft and enjoyed its positive environment as a student in the eighties. But, I believe that it has gotten (even) better. As one of the committee members put it "The place is full of happy, engaged and (relatively) relaxed people". This is a bit unusual for an internationally recognized university, I believe, and speaks highly of the Faculty. I wonder how much of this is thanks to the recent, and long overdue, overhaul of the academic career structure at the university. I left Dutch academia partly because of the limited freedom that was given to junior faculty in the past. The transition to a more US-like tenure-track structure and the power of promotion now also enjoyed by associate professors has empowered junior faculty, and I believe that this has contributed greatly to the level of satisfaction we observed in them during the site visit. This is not to say that we do not have some constructive criticism on the Faculty culture and government structure – we would not be much of a review committee if all we had was praise – but I believe that the Faculty can be very proud of the culture it created over many decades of excellence. It is a culture of scholarly generosity, strong mentorship and positive leadership at the department level.

The Faculty of Civil Engineering is internationally recognized as a center of excellence in research and education. We saw abundant evidence that this reputation is well-deserved. The Faculty has always been, and still is, a critical part of TU Delft. It has extraordinary relevance to society, not just in The Netherlands, but also globally (and if anyone in the Executive Board reads this foreword, please know that we all agree that Civil Engineering is the flagship of TU Delft). In the US, for example, Civil Engineering is well-known and regarded for its ground-breaking work on coastal protection. As ex-pat and TU Delft alumna, I was incredibly proud of the contributions Delft made after Rita and Katrina, and continues to make in many areas of the US and elsewhere.

The Faculty recognizes its importance in society: it is simply embedded in its DNA. One reason why the Faculty has been so successful is its strong collaboration with stakeholders through organizations like the Golden Triangle, and its many talented alumni who play leadership roles in industry and government. TU Delft is also known for its innovation and entrepreneurial spirit. That is reflected clearly in the Faculty of Civil Engineering. We saw various excellent examples of leadership and innovation, such as the Building with Nature program.

Any organization at the leading edge of research and education must continually improve and re-invent itself. Civil Engineering must do so as well. Society is also changing and new societal challenges are created to which the Faculty must respond. We were pleased to see that the Faculty



is willing and able to adapt. Its agility is to a large extent thanks to the open mindedness and strong foundational skills of its researchers. In the report, we highlight several areas in which we believe the Faculty can further improve and strive harder. One such area is diversity, particularly gender diversity. The departments have increased the percentage of female professors (at most levels), graduate students and postdocs, but the improvement has not been uniform and in very few of the units in the Faculty has the number of female faculty reached critical mass.

I commented above on strong leadership at the departmental level. We were particularly happy to see clear shared visions in the departments of Transport & Planning, Water Management and Hydraulic Engineering. The Structural Engineering department is going through a critical transition at this time – it recently split into two new departments - which we will address in the report in some detail. We believe that the new departmental structure is promising, but much work remains to be done to create strength and cohesion in these two new units. The chairs and co-chairs of the new departments are passionate and dedicated. They will only succeed, however, if they are given strong support from the other department chairs, from the dean's office as well as the university. Structural Engineering focuses on very important societal challenges like the largescale upgrading of the infrastructure of the last century. It is a highly valuable part of the Faculty, and of TU Delft, and should be given the necessary resources to rebuild stronger than ever.

We understand that the Faculty will soon see a transition in the dean's office, with Dean Bert Geerken stepping down. We thank Bert for his consistent and supportive management of the Faculty. We look forward to following the new Dean, at this critical phase of the Faculty of Civil Engineering and hope that he or she will benefit greatly from this report. We will certainly always be happy to lend advice and support.

As a final note, please let me apologize for the perhaps slightly informal way in which this report has been written. It's the American influence, I suppose. I will write in first person, rather than third, and so "we" simply refers to the review committee. It is also very well possible that from time to time I will refer to the Faculty of Civil Engineering as "the School", because that is the nomenclature generally used in the US, and to the tenure-line faculty members of the Faculty of Civil Engineering simply as "the faculty", with lower case f, as is the tradition across the Atlantic also. Any resulting confusions, or any other errors and inconsistencies in this report, are solely my doing: my committee members are without fault.

Again, thank you for inviting us to conduct this very interesting and thought-provoking review. We all hope that you will find the report useful, positive and constructive, as it was indeed intended.

As TU Delft alumna, I remember fondly the times I spent in Civil Engineering (in classrooms and labs as well as at parties put on by Practische Studie), and I am very proud of my connection to the Faculty, which remains a true global leader in the field.

Gefeliciteerd met jullie buitengewone prestaties,

Margot Gerritsen
March 2018
Stanford University



2. THE REVIEW COMMITTEE AND THE PROCEDURES

2.1. Scope of the review

We (the review committee) were asked to perform a review of research at four of the six departments in the Faculty of Civil Engineering and Geosciences at Delft University of Technology:

- Department of Hydraulic Engineering
- Department of Transport & Planning
- Department of Water Management
- Department of Structural Engineering

We will refer to this group of four departments as “the Faculty of Civil Engineering” or, in short, “the Faculty”. The other two departments in Civil Engineering and Geosciences were reviewed earlier separately. In accordance with the Standard Evaluation Protocol 2015 – 2021 (SEP) for research reviews in the Netherlands, we assessed the quality of the research conducted in each of these departments, the relevance of the research to society and also its viability. In addition, we reviewed the strategic targets of the Faculty and the four departments and the extent to which they are equipped to successfully meet these targets, and also conducted a qualitative review of the PhD training program, the research integrity policy and diversity.

In the Terms of Reference, three additional guiding questions were provided on which we were asked to reflect:

- Do all research units have enough focus and are they flexible enough to renew?
- Do all units have the ability/strategy to attract/recruit top scientists?
- Is there a good balance between short-term projects and long-term projects?

Our thoughts can be found in section 3.1. On request of the Faculty, we also reviewed the national research school TRAIL during the site visit, see the separate review in Appendix 5.

2.2. Composition of the committee

Our review committee consisted of:

- Professor Margot Gerritsen (chair), Stanford University, Stanford, US;
- Professor Marc Parlange, Monash University, Melbourne, Australia;
- Professor Joannes Westerink, University of Notre Dame, Notre Dame, US;
- Professor William Lam, Hong Kong Polytechnic University, Hong Kong;
- Professor Gerhard Müller, Technical University of Munich, Germany;
- Ir. Karin Sluis, Witteveen+Bos, The Netherlands.

Our curricula vitae are included in Appendix 2. We were supported in our work by Meg Van Bogaert, who acted as secretary to the committee.

2.3. Independence/impartiality

All committee members signed a Statement of impartiality and confidentiality to guarantee unbiased and independent assessment of Civil Engineering at Delft University of Technology. Personal or professional relationships between committee members and the research units under review were reported. We discussed these at the start of the site visit and determined that the committee was impartial and that there was no risk of bias or undue influence to occur during the review.

2.4. Data provided to the committee

We received the self-evaluation reports from the departments under review, including all the information required by the SEP, as well as:



- the Terms of Reference;
- appendices to the self-evaluation report;
- the SEP 2015-2021;
- and lists of publications, consisting of five key publications per department, and another five key publications for each of the individual research groups;
- Input by TRAIL Research School over the period 2013-2016 (see Appendix 5).

2.5. Procedures followed by the committee

We proceeded according to the SEP 2015 – 2021. In advance of the site visit, we all studied the documentation provided by the departments and the Faculty. Each department under review was assigned to two members of our committee, who were requested to independently formulate a preliminary assessment on the research unit under review, based on the written information provided. Please note that we all read the self-evaluation report of all research units and are jointly responsible for the review, the final ratings of the Faculty and departments and this report.

We based this final report on the written documentation provided by the departments and the information gathered during the interviews and lab tours at the site visit. The site visit took place from 3-5 February 2018 in Delft. On the first day of the site visit we were briefed by the secretary on the research review protocol according to the SEP, and provided with specific information on Dutch research (e.g. funding, organizational structure, and positions of PhD candidates). We also discussed the preliminary findings, decided on a number of preliminary comments and feedback, prioritized topics, formulated critical questions to be asked during the interviews, and agreed on procedural matters and other aspects of the review.

In between and after the interviews, we discussed our findings and formed preliminary conclusions, which allowed the secretary to draft a first version of the review report. This draft report was based on the discussions during the site visit and a preliminary review initiated by the chair and subsequently commented on by the other committee members. The draft report was verified and modified where needed by the full committee before being presented to the departments and Faculty for factual corrections. These suggested corrections were then reviewed by the secretary and incorporated in the final report in close consultation with the chair and other committee members. The final report was presented to the Executive Board of the University and to the Faculty management.

2.6. Application of the SEP and scores

We used the criteria and categories of the Standard Evaluation Protocol 2015-2021 (SEP), see Appendix 1. Care must be taken when comparing the outcomes of this review with previous reviews of the departments, or with reviews of related departments at other universities, as the bases for scoring may differ. In particular, be aware that:

- we gave the score 1 (excellent) only in those cases where the committee unanimously decreed the department deserved the overall judgement: “one of the few leading groups worldwide” (SEP definition). In this, we explicitly applied the scores as intended in the current SEP.
- the present SEP scores range between 1 (excellent), 2 (very good), 3 (good) and 4 (unsatisfactory), while those of the previous SEP ranged between 5 (excellent), 4 (very good), 3 (good), 2 (satisfactory) and 1 (unsatisfactory). A current *very good* (2) score should therefore be valued **higher** than the *very good* (4) score in the previous SEP, since the criteria for obtaining the score *excellent* are stricter in the current protocol.
- 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. For fair comparison, the qualitative comments in the reviews should therefore be included.



3. CIVIL ENGINEERING: GENERAL THEMES AND FINDINGS AT FACULTY LEVEL

We aim to provide constructive, concrete feedback to help improve the research community, the research quality, its impact on society and its viability. This chapter focuses on the whole Faculty of Civil Engineering. The individual departments (Water Management, Hydraulic Engineering, Structural Engineering and Transport & Planning) are discussed in chapters 4-7.

In this and following chapters, "Faculty of Civil Engineering", or in short "Faculty", refers to the combined four departments. Tenure-line professors in the Faculty may be referred to as "faculty members", or in short "faculty" (with lower case f), as is common in the US.

3.1. Mission

The Faculty describes its mission as (paraphrased) to conduct research and provide education of high international reputation, to contribute to a safe and sustainable living environment by educating engineers, conducting research and disseminating knowledge. The Faculty strives to be at the global forefront in all key disciplines represented by its four departments, to make strong technological contributions and develop breakthrough solutions for societal problems by capitalizing on its unique synthesis of cutting-edge science, engineering and design.

We saw clear evidence that the Faculty has successfully delivered on its mission: it is internationally recognized as a center of excellence in research and education; it is still, as it has been, a critical part of TU Delft; it has extraordinary relevance to society, not just in The Netherlands, but also globally, and societal relevance is part of its DNA; it is innovative and entrepreneurial; and its alumni make tremendous differences as leaders, educators and innovators nationally and internationally.

Requested reflections

In the Terms of Reference the Faculty requested the committee to reflect on three specific topics as part of this review. In this paragraph, we give our responses succinctly. More information on all three topics is provided throughout the report.

1. *Do all units have enough focus and are they flexible enough to renew?*

All four departments have sufficient focus and adaptability/agility, so the answer to this question is yes. Water Management and Transport & Planning present a clear focus and strong vision. They have also shown that they adapt well to new directions and opportunities. Hydraulic Engineering is seen as relatively small relative to its breadth of research interests and therefore adaptation (topic switching) is more challenging without expansion of the group. Structural Engineering is currently in a state of transition: it recently split into two smaller departments. The committee believes that this structural change (no pun intended) is timely and can lead to two more cohesive units rather than one large group. It is also logical that at this stage, the new departments are still formulating their missions and deciding on strategies. The committee is confident that the new department (co-)chairs will be able to take the units through this transition smoothly and quickly, provided they receive strong support from the colleagues, the Faculty and the central administration of the university.

2. *Do all units have the ability/strategy to attract/recruit top scientists?*

All four departments are able to attract, recruit as well as retain top talent, so the answer to this question is also yes. We discussed the hiring strategy and policy, both at Faculty level and within the departments, in depth. We also reviewed the (relatively new) tenure-track structure and analyzed its outcomes. Within the restrictions imposed by Dutch law, all departments have clear and effective strategies to attract high quality research staff. The departments are competitive internationally, which speaks very highly of the Faculty and TU Delft. The departments also seem to be able to attract top talent from industry and not lose talent to industry often. The diversity

amongst the hires is relatively high in terms of nationalities/cultural background. Gender diversity is still lacking in several of the departments. We address this in more detail below.

3. *Is there a good balance between short-term projects and long term research?*

We believe that there is a reasonable balance between short-term projects (with maximum duration of a couple of years) and long-term research programs. We base our opinion on information provided during interviews and tours of the facilities, as well as the funding information provided in the self-assessment reports. Funding seems to be reasonably well distributed. All departments receive adequate first and second stream funding, which is typically supporting long(er) term projects and often foundational research. The departments attract a healthy dose of third stream funding, which is mostly industrial sponsored research and generally focused on short(er) term research. One exception is EU funding, in particular Horizon 2020, that is counted as third stream funding, but often consists of long term and more foundational research. We are slightly concerned that strong dependency on third stream funding to support the large number of PhD students and postdocs may lead to a stronger focus on applied research at the cost of foundational research.

3.2. Leadership, management and organization

The management team (MT) consists of the Dean, department chairs and the Faculty Director of Education. The MT is responsible for strategic decisions on research directions, and major developments in educational and valorization processes. In this subsection we offer several comments and suggestions related to the organizational structure and leadership of the Faculty. We hope that these are particularly useful to the incoming Dean.

Leadership style

We were positively impressed with the overall management of the Faculty. The MT is well coordinated, knowledgeable and responsible. We did find some risk-aversion. The MT seems careful in its decision making and somewhat hesitant in taking bold(er) steps. Talking to faculty, we think it would be attractive, for example, to create a discretionary fund to seed innovative ideas in research and education developed by faculty and staff. This can be very empowering to faculty, stimulate bottom-up development, and help secure long term funding from outside sources after proof of concept. We also encourage the MT to not be too incremental in its hiring: if a department or research group is not at critical mass, providing several new positions at once, rather than over a number of years, to bolster the unit is more effective. This is also the case when it comes to diversity: incremental hiring will not lift the departments up to or above the desirable critical mass for quite some time.

Inclusion and transparency

Discussions with tenure-line faculty members left us with the impression that the MT can be more inclusive and transparent in its decision making at the Faculty level. In some departments, inclusion and transparency can also be improved at the departmental level. Junior faculty in particular seemed disengaged from strategy development and decisions at the department and Faculty level. The establishment of a junior faculty council could help create a stronger feeling of ownership, which will benefit the Faculty. We encourage each of the departments and the Faculty to reflect on its inclusion and transparency, and develop approaches for improvement.

Another idea would be to create an external advisory board that supports the MT in its strategic planning. At several of our universities, such external advisory boards at the Faculty level have proven to be very effective. The advisory board members can also provide strong strategic links to external research or educational partners.

Siloing

We liked seeing that the departments are not overly siloed: several strong collaborations exist across departments, and in general the faculty members, postdocs and students seem to feel that departmental boundaries are relatively porous. However, some siloing remains.



We believe that a couple of important cross-cutting themes can be strengthened. Examples are design thinking, which is relevant to all departments, as well as data-driven approaches (“Digital Civil”). We were particularly struck by Figure 7 in the self-assessment report, and discussed this in depth during the site visit. This figure shows that several inter-departmental connections are weak. We urge the MT to reflect carefully on this figure, and develop strategies to encourage deeper and broader cross-cutting collaborations. One suggestion is to create a matrix-structure for the school, which will emphasize cross-cutting themes and interdepartmental collaborations. We recommend this also because current societal challenges require very diverse teams.

In talking to the faculty members and staff, we understood that the undergraduate programs in the Faculty introduce material related to Transport & Planning and Water Management late in the degree programs. We recommend that space is created for these important areas in the earlier stages of the degree programs. This will improve integration of these topics in the curriculum, which we think is important for the modern civil engineer, and will help create stronger linkages across departments also.

New structure of SE

During this last review period, Structural Engineering made the bold decision to split the department into two more cohesive units. The resulting two new departments, Engineering Structures (ES) and Materials, Mechanics, Management & Design (3MD) are now being formed. Both have strong and enthusiastic chairs and co-chairs, who are dedicated to the success of the new departments. Although we understand that the old SE was too diverse to develop a strong shared departmental vision, it is not clear to us that the new departments will not suffer from the same. We discuss this in more detail in chapter 7. It is very important that TU Delft, the Faculty and the MT support the new chairs in the difficult task of shaping ES and 3MD and provide the necessary advice and resources to set these new departments and their chairs up for success.

Web presence

The quality of the departmental and Faculty webpages varies strongly. Some of the pages provide easy navigation and in-depth and current information on research, educational programs people. Others do not. The lack of a uniform look and feel also makes the web presence of the Faculty as a whole a bit messy and hard to navigate. It is difficult in general to find faculty members in the school, for example, as each unit lists the faculty members differently, and name recognition is hampered by the use of initials rather than full first names. We therefore recommend that the webpages are redesigned to provide a more uniform look, that they are regularly updated and that people are listed in the same way in each unit. As far as the people is concerned, we recommend that PhD students, postdocs, research staff and faculty members are listed in separate categories for easier browsing, and that all faculty members are listed together rather than in separate rank categories to avoid the impression of a strong hierarchy in the department. Also, a short description of the main research interests of each faculty will ease browsing significantly.

3.3. Collaborations

The Faculty has strong links to industry and government. We were very positively impressed with its strong role in the Golden Triangle system, a collaboration between public authorities, industry and academics, which is an effective driver of the Faculty’s research agenda. The strong interactions between Golden Triangle partners also allow the Faculty to conduct research that is directly relevant to society, disseminate research findings and design ideas quickly and effectively to industry, government and NGOs (e.g. sand engine and soft coast concepts). It furthermore facilitates funding pathways and increases the success rate in fund-raising activities, enhances training of students and postdocs, and also helps create a strong market for its graduates. Committee members from outside the Netherlands were particularly struck by the Golden Triangle system, which seems superior to the funding models used elsewhere. We believe that The Netherlands is overall better positioned for this type of exchange because more technically highly educated people occupy senior positions outside academia, and there is a stronger tendency to think long-term.

Many of the faculty members in Civil Engineering also collaborate with colleagues at other technical universities (Eindhoven, Twente, Wageningen) and with those at related research institutes (such as TNO and Deltares). We did not find many collaborations with the HBO institutes (Universities of Applied Science), which surprised us as it seems that such collaborations could also be very fruitful.

The Faculty perhaps is not taking as much advantage as possible of collaborations with other schools across TU Delft. In particular, we were surprised to see only a few of the faculty members associated with the Computational Science & Engineering initiative, which for clear reasons is very relevant to Civil Engineering.

3.4. Culture

We were struck by the collegial and supportive environment in the Faculty. As one of the committee members put it "The place is full of happy, engaged and (relatively) relaxed people". As the chair mentioned in her foreword, this speaks highly of the Faculty. We believe that this is in part thanks to a relatively low demand on faculty members for teaching and service (see also below) and a smooth transition to a new tenure-track system that is seen as fair and transparent. We believe that the Faculty can be proud of the culture it created, which is one of scholarly generosity, strong mentorship and positive leadership at the department level. The junior faculty are also talented, driven, dedicated and passionate.

As we mentioned above, we believe that a stronger inclusion of junior faculty in strategic planning, and an improved transparency at the MT will contribute positively to the culture by empowering this critical group of faculty colleagues and giving them ownership. We also insist that the Faculty will move strongly to increase the number of female faculty to critical mass (30%).

3.5. Funding and Facilities

Funding

In 2012 direct funding provided by TU Delft to the departments decreased because of budget cuts resulting from a university-wide reorganization. A new strategic plan and allocation model led to an increase in direct funding in the years following 2012. TU Delft does not support postdocs nor PhD students from general funds. The faculty and departments rely on national funding, EU funding and industry contracts to support these critical groups of researchers and research assistants. The departments have been successful in attracting these funds and we feel that overall research support is healthy. However, with a large dependence on third stream funding, there is a risk that foundational research, primarily supported in first and second stream funding, may suffer in the long run. It is clear that the departments and the Faculty strive to conduct high quality scientific research. To support foundational research, larger affiliates programs (consortiums) could be considered, which can generate, in addition to funding for sponsored projects, also base funding for longer term research. This model is popular at other universities (particularly the US). Such programs can also contribute well to collaborative, interdisciplinary research in the school.

Facilities - laboratories

The laboratories we visited are generally world class and appear to be solid anchors of the departmental programs. The laboratories provide a rich learning and research environment for MSc and PhD students, as well as postdoctoral fellows. The facilities are also a significant advantage when recruiting talent from across the globe: few Civil Engineering schools are as well-equipped as the Faculty at Delft.

We strongly advise that all laboratories are well maintained and supported. In particular we urge TU Delft to continue its support of the fluid mechanics/hydraulics/coastal engineering laboratory at its current state: remote facilities, with limited access, are not a suitable substitute.. Experimentation will continue to be a vital part of research in this area, into the foreseeable future. Shared facilities at the Deltares site may work, provided that research staff have free and open access. One of our committee members notes that his institute eliminated its physical fluid mechanics laboratories two



decades ago, regrets this decision and is now rebuilding infrastructure as well as technical expertise at great expense. This must be avoided.

Computing facilities

We believe that Civil Engineering is currently lacking in high performance computing resources. Investing in this infrastructure on-site, or providing access to shared HPC resources in Delft or elsewhere, is as critical as investing in state-of-the-art analytical facilities. This is particularly important for the groups that develop popular and excellent codes, such as SWAN, SWASH or DELFT3D.

Other support

The Faculty and departments have strong technical support and sufficient administrative support. We were also happy to see good scholarly support (e.g. proposal writing) provided to the faculty members and researchers in the Faculty.

3.6. Tenure-line faculty members

Hiring

All departments have a clear vision and well-thought out strategy for recruitment of top research staff. The junior faculty are talented, driven, dedicated and passionate. Priority areas are set strategically at the departmental level and at the Faculty level, and retiring faculty are not automatically replaced by researchers with similar expertise and/or interests. This has allowed the departments and the faculty to respond well to new research directions and collaborative and funding opportunities. All departments seek to attract and hire diversity candidates, particularly women, with some departments more successful than others in growing the percentage of female faculty.

We have a concern related to hiring: a relatively large number of PhD students, postdocs and assistant professors seem to be home-grown. During interviews, PhD students and postdocs often told us that they want to continue their career in the Faculty, and moreover that they expect they will be able to. They were often a bit surprised when we suggested to apply to positions elsewhere, to be exposed to different research cultures and programs and gain expertise and skills that complement those offered at TU Delft. We did not receive data on the number of home-grown researchers, at any level, but anecdotally, the percentage of home-grown researchers seems relatively high. We feel that the Faculty is missing opportunities to attract diverse opinions, skillsets and interests to the Faculty and departments. It encourages the Faculty and the departments to carefully analyze hiring at the PhD, postdoc and junior faculty levels and understand possible biases in recruitment.

Mentoring and promotions

We were impressed with the mentoring and development programs for junior faculty. The Faculty recently adopted a tenure-track (TT) program for assistant and associate professors, which is strongly supported. Some of the junior faculty interviewed during the site visit were going through continuation or close to tenure decisions. They were all very positive about the support provided by the faculty, the departments and their mentors, and did not strike us as being overly stressed or anxious about the process: expectations were clear; the process was transparent; the junior faculty were well mentored and guided; and feedback was provided to them along the way to help them prepare the best promotion packages possible. All of the junior faculty we met were highly engaged, happy, and expressed that they felt productive and valued. This overall positive and supportive work environment is an outstanding achievement of the Faculty and the departments.

Junior faculty also have, based on interviews, some or sufficient freedom to choose their own research directions, although the degree to which they feel empowered to do so varies from unit to unit. Assistant professors do not yet have the power to promote at TU Delft. In this aspect, the TT structure differs from the tenure-line programs of universities in the US. The lack of power to promote

means that assistant professors are still dependent on the senior professor(s) leading the research group, which can be restrictive.

With only one or two exceptions, all faculty members interviewed felt that teaching and service duties were reasonable and fair. We also commend the Faculty on the creation and successful implementation of the formal teaching course. A pain point brought up (particularly by assistant professors) is the advising of MS students. Some of the junior faculty reported having to guide very large numbers of MS students without much support from senior colleagues. Altogether, we feel that the teaching duties are (more than) reasonable and fair particularly in comparison to colleagues at other institutions (including those represented by several of us). The target time distribution of 40/40/20 for research, teaching and service, respectively, is not seen amongst junior faculty members. The distribution seems closer to 65/25/10. Although that has the advantage that junior faculty members can focus more on research, it comes at the price of having less engagement of junior faculty members in the departments and Faculty.

3.7. Societal relevance

Sustainable development goals

Civil engineers can contribute very strongly to addressing current and future societal challenges, such as clean water and sanitation for everyone, the energy transition from fossil fuels to renewable energy resources, climate adaptation, the circular economy, safe cities and communities, and innovative infrastructure. We therefore were pleased to read that the Faculty Civil Engineering is guided and inspired by the 17 Sustainable Development Goals (SDG) of the United Nations. Also during our interviews and lab visit we sensed great enthusiasm to contribute to the SDGs. This is strongly supported and appreciated.

We did not get a sufficiently clear understanding on how the departments view the balance between societally driven research and foundational research. Civil Engineering seems to be focusing strongly on funding opportunities from the third stream. This might lead to diminishing of foundational research in the long term, and we encourage the Faculty to keep a close eye on the balance.

To further increase its contribution to the SDGs, Civil Engineering should sharpen its strategic and integral thinking on societal impacts. We recommend that the full Faculty (all departments) discuss this topic on a regular basis, for example once per year. Questions that can be addressed in such discussions include: What challenges does society face? Which of these do we already sufficiently address? Which can be new areas of research and innovation? What mix of foundational and societally driven research is optimal/ effective for the Faculty, as well as society at large?

Networks in society

Societal challenges cannot be solved by the Faculty of Civil Engineering alone and strong collaborations with external partners are essential to create optimal and sustainable solutions. We were pleased to see such external collaborations and connections are in place and actively pursued. Civil Engineering has close ties to several DRIs as well as inter-university research programs such as the Urban Mobility Lab. In The Netherlands, Civil Engineering is strongly involved in the Golden Triangle and plays a significant role in the Topsector Water and Maritime. In the areas of transport and infrastructure, Golden Triangle connections can be improved and we recommend strengthening ties with Topsector Logistics.

The impact of placing graduates in industry, government and academia cannot be understated in the context of societal impact and relevance. For example, (originally) Dutch consulting firms have enormous impact on coastal management in the US, and not in the least thanks to contributions from TU Delft.

More extensive collaborations with Universities of Applied Science (HBO) as well as other TUs in The Netherlands and neighboring countries can be very attractive going forward. Current HBO



connections are limited in number and scope, and they mainly focus on education, not research. Especially in an overheated labor market the alignment of research agendas between the institutions can increase effectiveness and impact.

Integral Design

The best solutions to societal challenges are integrated solutions that are based on principles such as nature-based design, circular thinking and multi-functionality, and involve all stakeholders. We are excited to see that Integral Design has a recognizable position in the Faculty. However, Integral Design is underdeveloped and under supported in the Faculty. We strongly recommend that Civil Engineering supports growth and strengthening of this critical cross-cutting activity.

Monitoring impact

During this assessment, we read and heard a lot about societal impact in terms of newly developed products, computer programs, patents and spin-off companies. We also understood that Civil Engineering is often asked to participate in external advisory boards, providing input and valorization. Our impression is that the indicators that are used to monitor and enlarge societal impact vary wildly across the departments. We therefore recommend that this issue is discussed extensively at the Faculty level and that a shared vision is created: What level of societal relevance is desired for the Faculty? How could the Faculty better guide, prioritize and monitor the adoption and implementation of research outcomes in government and industry, and which are the critical metrics to track in this context? For this assessment we decided to specifically focus upon the following topics to value societal relevance: contribution to the SDG and networks in society.

3.8. Diversity

TU Delft interprets diversity broadly; it includes age, culture, nationality, gender, social background, sexual orientation, disability and disciplinary background. The current focus of the Faculty is on gender diversity, and in particular on improving the recruitment, selection, career development and retention of women faculty. In this area, TU Delft recently created the Delft Technology Fellowship, which offers tenure-track positions to internationally recognized female scientists and engineers in the fields represented at Delft. In another recent gender diversity program, additional resources are provided to a number of female assistant professors to accelerate their promotion to associate professor within two years. The Faculty and department have made use of these programs in this last review period.

The main strategy at the Faculty for increasing the number of female candidates in faculty searches is to have broad searches and cast a wide international net. The Faculty set an ambitious goal of 23% female faculty overall by 2020. The current average percentage is 16%. Although this represents a positive change as compared to the last review, the rate of change is low and significant efforts will need to be put in to achieve the set Faculty goal in two years' time. Also, the diversity numbers, and reported targets, vary strongly from department to department.

We were sufficiently impressed, however, with the success in gender diversification in the department of Water Management (WM). The female faculty there are strong, passionate, and impressive and the greater diversity has helped create a more open and collegial culture. The difference between WM and other departments in this respect was noticeable.

We recommend that bold initiatives are created in the other departments to reach critical mass at all levels, including leadership. The 23% target is laudable, but research has shown that for sustained and impactful change to occur, a critical mass of 30% or higher is necessary. In some departments the targets are below 23% and should certainly be adjusted upwards.

The current hiring strategy may not be sufficiently effective either. When the percentage of female faculty is low, incremental positions may leave new junior faculty feeling isolated. We recommend that instead of hiring one new faculty periodically, the departments hire several diverse faculty at once (and wait longer in between hiring sessions if necessary). We strongly encourage the

departments, and the Faculty, to walk the talk: if they are serious about increasing the number of female faculty, be bold and get to critical mass fast. We believe this will have significant and positive impacts on the departments.

We were concerned with the (seeming) lack of senior female faculty in leadership positions. In the last review period, all department chairs and the dean were male. In the upcoming review period, it seems that there will be one female co-chair. We encourage the Faculty leadership to carefully analyze reasons for this low diversity at the top and put in place leadership succession programs that ensure that improved gender balance will be possible in the future and any real or perceived barriers to leadership for female faculty are removed.

With respect to cultural diversity and diversity in nationalities, we observed a significant variety, specifically at the levels of junior faculty.

3.9. Research Integrity and metrics

In the self-evaluation report the Faculty describes a number of measures to ensure research integrity. These include the Code of Ethics of the TU Delft and the course on scientific integrity that all PhD students are required to take. In addition, data privacy rules are clearly communicated to staff as well as external partners, and a TU Delft Integrity Roadmap was designed to guide staff when they suspect any violations.

We conclude that all systems and procedures are in place, but we noticed in the interviews that this topic is not seen as very important in daily practice. No signs of problems were observed at this stage, but we encourage the Faculty to make this a regular point of attention and discussion, particularly in this day and age in which data-driven research is becoming increasingly critical.

In terms of metrics of research success, we found an emphasis on index-related metrics (citation indices, H-index). We want to add a note of caution as over-reliance on such metrics is inherently problematic in an area like Civil Engineering across which publication practices and cultures differ strongly. It is therefore hard to avoid comparing apples to oranges. Also, a focus on research metrics like this may lead to an undervaluation of areas that are nonetheless critical to the Faculty and to society (for example, the structural laboratories). The Faculty should carefully evaluate the metrics it uses for success of its faculty members, staff and students, and make sure that a variety of metrics is introduced tailored to its diverse areas of expertise.

3.10. PhD program

During our site visit, we met with several groups of PhD students, and also received an informative presentation on the Graduate School (GS). The GS was established by TU Delft in 2012. The main goals of GS are to help creating a supportive and stimulating work and study environment for the graduate students, and to provide PhD students with opportunities for professional development. The GS is structured in Faculty Graduate Schools (FGS) and centrally coordinated.

After five years, the GS seems well established and effective. We were very pleased to hear that it recently created a PhD council to act as an intermediary between the approximately 500 PhD candidates and the GS.

PhD culture

Overall the PhD students feel well supported by their mentors and through the GS, and seem comfortable and happy. We also found them to be relatively stress-free as compared to graduate students at some of our own institutes.

Each PhD candidate has two supervisors. The daily advisor and co-promoter is typically an assistant professor. The formal supervisor and promoter is usually a full professor, but with the recent legal change with respect to *ius promovendi*, associate professors are also eligible. The PhD students appreciate this mentoring structure as it ensures that they receive frequent guidance even when



their promoter is not available often. They also were positive about the GS, and teaching opportunities provided in the departments.

The students commented very positively on the opportunities for skills development and growth as well as the support provided by the GS. They also see this as an effective structure through which to meet and connect with other PhD students.

Ius promovendi

We are very positive about the recent change to allow tenured associate professors the power of promotion. We would much like to see the same power given to assistant professors, as is common in many international universities. We understand that this is not in the hands of the Faculty or even TU Delft, and appreciate the current co-promoter solution, but we hope that the Faculty will continually put pressure on TU Delft to advocate for this change. It will empower and inspire assistant professors and will make the Faculty more attractive to young top talent who are strongly self-driven and do not want to wait till tenure for full independence and self-determination.

Duration and drop-out rates

The long average duration of the PhD remains a challenge. The total drop-out rates also seem relatively high (15% average). We recommend that the Faculty studies this drop-out rate in more detail to understand causes and develop solutions when necessary.

The Graduate School (GS) streamlined the PhD process to help alleviate these problems. It improved the selection process of PhD students (in particular the interview process and due diligence on candidates from lesser known universities) which has led to incoming cohorts with a stronger background and better qualifications. It institutionalized a thorough vetting process in the first year, with strong mentoring and advising a Go/No-Go decision after 9 months of studies. This decision is made by a committee that does not include the promotor.

We understood that not all departments have fully adopted this Go/No-Go system yet. We urge them to do so to help lower the drop-out rates in later years and shorten the average duration of the PhD program. Annual research progress meetings should be held throughout the PhD program also.

The Faculty should also take a deeper dive into the data to better understand the reasons for overly long PhD programs and high drop-out rates. It is not clear, for example, if students on scholarship generally take longer (which would not be entirely unexpected as faculty members do not have as much at stake if such students take longer). It was also not clear to us if the drop-outs mostly occur as a result of the Go/No-Go process, or are caused by other factors in later years of the PhD program.

Home-grown PhD students?

During the interviews, we got the impression that many of the PhD students in the Faculty are home-grown (that is, have an undergraduate degree from TU Delft). The exact percentage of own students vs students from outside universities is unclear. We understand that TU Delft provides strong undergraduates, but we appreciate diversity of opinions and backgrounds, and believe that the Faculty should understand its selection process, and possible (un)conscious biases that may favor home-grown candidates over others, better.

Doctoral Education Program

To widen the educational horizons of the PhD candidates, the Doctoral Education Program was developed. PhD students are required to participate in a number of courses and activities covering areas of specific technical knowledge, of general research skills, and of "soft" skills, like communication and time management. Each PhD candidate sets up his/her own tailored Doctoral Education program that should be completed before defense of the doctoral dissertation.

We strongly support this program: it is important for PhD students to develop a broad skillset, particularly in modern engineering where engineers are required to work effectively in

interdisciplinary projects and quickly adapt to new challenges and technological developments. This is equally important for graduates who want to stay in academia. Several PhD students we interviewed mentioned that they feel restricted by having to select 15 EC's in each category. We do not believe that this is necessarily a problem, but encourage the Faculty to strengthen the role of the (daily) supervisor in course selection. This means that supervisors have to understand and support the Doctoral Education Program.

The domain specific courses in the GS are often coordinated and designed by the National Research Schools, e.g. TRAIL. We think that the National Research Schools are excellent and can provide PhD candidates with state-of-the-art courses in relevant areas. Unfortunately, a National Research School is not available for all PhD candidates in the Faculty. These PhD candidates have to look for appropriate courses and summer/winter schools, which is not always so straightforward. We understand that Delft cannot introduce National Research Schools on its own for relatively small group of students, but it should support these students better and provide a strong and well-organized course program.

3.10. Postdocs

We very much enjoyed our discussions with postdocs in the four departments. As with the PhD students, the postdocs seem happy and relatively stress-free. They also feel valued and well supported by colleagues and supervisors and reported some freedom in setting their own research agenda, which we really appreciated.

We were struck that many of the postdocs seem to be home-grown (that is, received their PhD in the Faculty or elsewhere at TU Delft). This surprised us as it is not very common in our own institutions for PhD students to stay on: we usually encourage them to go elsewhere to receive a broader perspective. As with the PhD students, it was not clear how many are home-grown, and whether or not the selection process for postdocs is biased towards favoring own students over outside applicants. We ask the Faculty and departments to study this in-depth.

The postdocs seem very comfortable, almost too comfortable, in their positions. They did not come across as particularly motivated to look elsewhere for tenure-track positions and many assumed they could stay on as researchers or faculty members. This is surprising. They also seemed somewhat ignorant with respect to research done elsewhere, and maybe feel too comfortable at TU Delft. It is of course better for a researcher to be curious and eager to learn from others. In as far as this reluctance to leave is caused by lack of exposure, or lack of diversity in the incoming postdoc cohorts (in terms of background and experiences), the Faculty should endeavor to change this culture.



4. QUANTITATIVE AND QUALITATIVE ASSESSMENT OF THE DEPARTMENT OF HYDRAULIC ENGINEERING

4.1. Introduction

Safety against flooding and the sustainable development of rivers and deltas is of utmost importance for The Netherlands and other deltas. Population growth and climate change put further pressure on this issue. The research program in Hydraulic Engineering develops knowledge about the physical and natural processes and links it to engineering models and design approaches in order to come to effective, sustainable and multi-functional solutions. The field of application covers the full range from the ocean to offshore and coastal areas and further inland to estuaries, ports/harbors, rivers and lakes.

4.2. Research quality

The Department of Hydraulic Engineering (HE) has had a long tradition of solving fluid flow problems related to deltaic and coastal ocean environments. The department is clearly organized into inter-related sections, each with strong sub-disciplinary depth: Hydraulic Structures and Risk; Coastal Engineering; Rivers, Ports, Waterways and Dredging Engineering; and Offshore Engineering. The department's overarching core research themes are also well defined and include sustainable infrastructure and nature based solutions, renewable energy in the marine environment, dynamics of marine and inland system and climate and flood risk management.

While focused on physical fluid flow processes, there are strong and natural linkages to the Department of Water Management. The Netherlands' relationship with the sea and navigation is strongly reflected and has certainly driven the research in the department. The placement of the department's graduates has been extremely strong in industry, consulting, government, and academia. There is no question that Dutch expertise in coastal, estuarine, and riverine dynamics is renowned globally and extensively sought after. The department has been a global thought leader to evolve creative new solutions for solving problems in deltaic and coastal systems. For example the theme of building with nature and nature based systems is being rapidly embraced and implemented in the United States in the wake of a sequence of disastrous hurricanes. Furthermore coastal ocean processes software developed by the department including SWAN, SWASH, XBeach, and FinLab (as well as key contributions to DELFT3D) are globally embraced. For example SWAN and WAVEWATCH 3 (the latter developed by a TUD alumnus) account for the vast majority of non-phase resolving wind wave forecasts and analyses globally. The department's top reputation is reflected in the 2017 Shanghai Global Rankings of Academic Subjects, in which TUD was ranked world first in Water Resources.

Each section in the department has an excellent senior leadership team and a significant range of strong and highly engaged junior faculty at the assistant and associate professor levels. In particular there have been very successful well focused recruitment efforts in response to faculty retirements. The department faculty collectively has excellent publications in the leading civil engineering, coastal engineering and geophysical journals. The quality of the publications is superb. Funding in the department is diverse, robust, and growing. The partnerships with Deltares, TNO, and Marin as well as strong linkages with Rijkswaterstaat and private sector companies such as Arcadis, Royal Haskoning, Shell, and Witteveen+Bos benefit the program substantially with a very healthy two way flow of people, problems, ideas, and solutions.

The department's expertise is comprehensive and spans across theory, large scale field experiments, laboratory experiments, and computations; an appropriate and needed approach to maintain a leadership position. Large scale experiments such as the Sand-Engine mega nourishment experiments are center pieces of the building with nature theme and are cutting edge. The departments' physical laboratories are extensive and amongst the best in the world. We did think that recent reductions in physical laboratory space and the MOU with Deltares should be carefully considered. The anchor larger laboratory scale physical facilities will continue to play a vital role in

innovation together with prototype and field measurements and experiments as well as computations. Keeping and evolving in-house laboratory facilities with state of the art tools will be critical for the future. In addition, while the department has recently acquired a 240 node computing cluster, given its current leadership position in developing computational models of the coastal ocean, larger dedicated systems would be appropriate and will become more necessary in the future with model process and scale integration. For example, both downscaling and interlinking models from global to riverine scales will require significant computational resources. In addition, stronger ties to Delft's Computational Institute should be developed to ensure that discretization algorithms and coding paradigms remain state of the art.

The department graduates a large cadre of 100 master's students and between 15 and 20 Ph.D.'s per year. This is a significant level of productivity. All these students appear to be engaged in the department's research enterprise to mutual benefit, especially to the younger faculty. Furthermore these students continually add to the large and very successful alumni base in the Netherlands and abroad.

4.3. Relevance to society

Sustainable development goals

Hydraulic Engineering (HE) can contribute to many SDGs such as good health and wellbeing, renewable energy production, sustainable cities and communities, climate action, live below water and live on land. HE conducts research in most of these areas and this research is recognized and well appreciated. We would like to express our explicit appreciation for HE's contribution to research on building with nature and the global and critical role HE takes in this research area. We judge building with nature as a strong example of leadership and innovation that is not merely motivated by availability of funding. HE has a strong base in fundamental research and a healthy mix of computer/lab/field work. Much of its fundamental research leads to strong contributions to applications down the line.

We are convinced that HE can enlarge its impact on the SDG even more by integrating other aspects in its research, such as agri and food, circular thinking, finance concepts and use of big data, artificial intelligence and social media. We appreciated the open attitude of HE that was encountered during the discussion on these topics.

Networks in society

HE is very well connected to society, both in The Netherlands as worldwide. HE definitely uses its home market in The Netherlands to propel research and create possibilities for field experiments and living labs. We would like to express our special appreciation for the activities in the Topsector Water and Maritime and the Ecoshape consortium.

HE has a strong position in international research networks and is recognized around the world for its relevant research. Researchers at HE are frequently involved worldwide in advisory boards and are well connected to many regions with flooding problems, both in countries like the US as in upcoming countries. Many bilateral networks are in place to share knowledge, solve specific problems and build joint educational programs. We specifically value the activities of HE in developing countries vulnerable to flooding such as Myanmar and Vietnam, focused on both research and capacity building.

HE is well connected to public authorities and the industry as can be concluded from the great amount of joint projects, co-authored publications and co-financing of several chairs. Several researchers have performed in public media, explaining for example building with nature and flooding issues by this means explaining the relevance of their work to the general public, from school children to adults.

4.4. Viability

Faculty retirements were looming in the previous review and these have been well addressed. A broad range of key hires at all levels including the repatriation of a renowned scientist from the



University of Miami, strong international hires such as Jeremy Bricker, and key private sector hires such as Bas Jonkman have provided excellent senior leadership as well as established a strong team at the junior level as well with depth for growth. Young enthusiastic and creative junior faculty seem to be happy, highly engaged, and well mentored. We think that the evolving tenure track system will make the department more competitive in attracting international faculty but that at the same time the level of preparation for teaching and mentoring by senior faculty are helpful at the beginning of an academic career. There appear to be more international faculty and women faculty. The work load for faculty appears to be well defined and balanced between research and teaching with a smaller service component for junior faculty. The junior faculty did not feel stressed out or overworked.

Important new directions have been embraced and established that address the problems at hand in new ways including interfaces to global climate, infragravity waves, ecology, and downscaling systems to improve parameterizations. Key hires have been made to expand the expertise base for the department in new directions that allow the coast to be viewed and analyzed more holistically.

The strong interface with knowledge institutes, government agencies, consulting and industrial companies in the private sector both in the Netherlands and abroad as well as the balance of fundamental and applied research will continue to drive research in the department. The department is fortunate in that the deltaic and coastal ocean problems that drive its research and teaching are local and understanding and addressing them has enormous impact (and not addressing them has dire and substantial consequences). Furthermore, these same problems exist globally which has in fact made The Netherlands the leading technology exporter in this domain. The strong industry-government-university partnerships have been of enormous benefit to the department and to the Dutch Water Sector. These partnerships define a best practice and are certainly enhanced by the highly trained MSc and PhD alumni base which helps maintain this two way interaction in defining key problems, developing funding streams, finding solutions, and adopting better solutions in practice. Furthermore, the part time and full time faculty coming from industry add enormously to the department's strengths (despite their initially lower publication rates and h-factor). The department's SWOT analysis presented in the self-assessment is realistic. For example, the Ports and Waterways section should indeed be staffed with full-time senior faculty. In addition as noted, we feel that computational resources are a key future investment in carrying on the department's tradition of developing coastal ocean processes software tools.

4.5. Conclusion

The department's historical reputation, the global relevance of its research, and its ability to evolve in new directions and success in hiring appropriate faculty, lay an excellent foundation to be able to continue to thrive and therefore attract top faculty.

4.6. Overview of the quantitative assessment of the research unit

After having assessed the research quality, relevance to society and viability, and comparing that to the developments and standard in the field of Civil Engineering, we come to the following quantitative assessments:

Research quality:	excellent (1)
Relevance to society:	excellent (1)
Viability:	excellent (1)

5. QUANTITATIVE AND QUALITATIVE ASSESSMENT OF THE DEPARTMENT OF TRANSPORT AND PLANNING

5.1. Introduction

The research program on Transport & Planning (TP) models transport systems with a focus on supply & demand, the opportunities of ICT and the influence of travel & driving behavior with a focus on how to solve traffic congestion. Intermodal transport systems and connecting infrastructure connects the research program to the Faculty.

5.2. Research quality

TP has shown to be one of the most impactful departments in the world in its particular field. The quality of the research is internationally recognized. One example is the 2017 Shanghai Global Rankings of Academic Subjects, in which TU Delft was ranked first in Transportation Science and Technology. The position of the Delft TP group in the research community continues to grow, particularly on topics at the frontier in research and relevance. We are impressed with the strong recognition the department receives, both nationally and internationally, evident from the large number of grants, awards and honors. The department has great potential for securing more high-impact research funding and producing more high-quality papers for publication in top SCI journals in the future. This international recognition allows the department to attract strong new staff members and continue the excellent research.

TP made fundamental research contributions to four important and emerging transportation core application areas: (1) Cooperative and Automated Driving; (2) Active Mode Mobility; (3) Coordinated and Cooperative Network Traffic Operations and Management; and (4) Reliable Multimodal Transport Systems. Special attention was given to new technology and new types of traffic behavior in view of the self-driving cars. One major project is concerned with the spatial and transport implications of cooperative and automated-driving vehicles. With this project, new mobility concept is introduced in order to reduce amount of road space and parking garage used for transport.

A new smart city institute, the Amsterdam Institute of Advanced Metropolitan Solutions (AMS), was recently created. The challenge addressed by the institute is to determine the optimal mix of different transport modes, including the unique Dutch twist of cycling and walking, for health and sustainability. AMS provides opportunities for collaboration with local industry and municipality as well as international options, including EU collaborations on urban mobility, and collaborations with colleagues in other regions such as China and Australia.

We were impressed with the positive group feeling and atmosphere in the department. However, TP should pay attention to not becoming too self-confident. We did notice a lack of self-criticism, both in the self-evaluation report and in the interviews. Although the quality of the research and the reputation of the department are currently excellent, improvements and changes are required to remain world-leading in the field of Transport and planning.

Emphasis on interdisciplinary collaborations was very well demonstrated by joint projects and papers with national and international partners in the field. Attention was given to the balance between fundamental research inspired by and applied to the engineering practice for technology development. On the other hand, the integration in CEG could be strengthened by initiating connections on e.g. asset management, railroad, ports and harbor management.

We noted that in the review period the publication strategy was adapted, resulting in a substantial increase of journal publications. To be able to obtain personal grants, staff members are required to publish papers with a relevant track record. However, we observed a focus on quantity rather than on quality, specifically in more junior faculty members. It is a challenge for senior faculty members to mentor junior colleagues on how to balance quantity and quality for their career development.



5.3. Relevance to society

Sustainable development goals

TP can contribute to a broad variety of SDG's such as good health and wellbeing, innovation and infrastructure, sustainable cities and communities, and responsible consumption and production. TP conducts research in some of these areas with a focus on mathematical modelling and increased efficiency of transport systems. A very specific and high valued research theme is active mode mobility. We are convinced that this is an innovative and very relevant subject with a strong Dutch base.

We recommend that TP thinks carefully about increasing its potential impact by extending the present research focus on efficiency and by paying strong attention to the spatial impact of transport solutions, knowledge transfer to design components, and safety and sustainability (air quality, noise, health, social cohesion). In this respect we discussed rehabilitation of the Planning in TP's name.

We also suggest that TP thinks about its potential role in ethical and institutional questions related to automated driving. These issues should not be left to legal experts as effective solutions require domain expertise that TP can offer, while currently TP seems to predominantly focus on the technology aspects.

Finally, we recommend that TP and Structural Engineering (SE) pay attention to the big societal challenge of sustainable infrastructure renovation perhaps through the Dutch Top sector Logistics.

Networks in society

TP has excellent and extensive collaborations in traffic management, multimodal transport systems and automated driving in The Netherlands, both with public authorities as well as the industry. We have seen evidence of joint research, of co-publications and several cases of co-funding of researchers and professors. The group is productive, both in terms of articles as well contributions to conferences.

We highly value TP's desire to further extend its reach and impact. It is convinced that the participation in the Amsterdam Institute of Advanced Metropolitan Solutions and the increased connection with other disciplines, including behavioral scientists, creates strong possibilities to do so. We suggest TP to think about possibilities reach out to not only the experts in the field but also to the general public. And our last suggestion to further improve the societal relevance is to contribute to less developed countries. Active mode mobility gives excellent opportunities to do so.

5.4. Viability

In the evaluation period TP continued with the plan for replacement of the retiring staff members to strengthen scientific positions, focusing on scientific and educational excellence. This plan entailed the recruitment of several young and talented people to fill the open positions of tenure-track (TT) assistant professors. We were impressed with the enthusiasm of the research staff and faculty members, and their team spirit under the leadership of the new department head. The recruitment strategy is forward looking and brings diverse faculty and staff, also with non-civil engineering backgrounds. The junior faculty members are supportive to their department, as new opportunities are created for them to participate in departmental strategy discussions and future activities.

The TP research strategy is based on a strong shared vision on fundamental research and core application areas in emerging transportation topics. A coherent set of research tools and datasets provides economies of scale, flexibility and opportunities for further development of the TP department such as spin-off companies.

The strengths and opportunities of TP have been well addressed in the recent SWOT analysis with good insights and ideas for the departmental development in those areas. However, weaknesses and threats of the department can and should be further elaborated. In particular, collaborations with the other departments in the Faculty can be strengthened.



The transportation problems and emerging research topics have been changing rapidly due to the advancement of technology development in the field. These new research challenges will be embedded in the smart city context. With the four core application areas TP is well-positioned to develop the scientific theories, methods and applications to address these critical issues. In addition, the department will foster the overlap between its core application areas to increasingly develop the integrated theories and approaches. The inter-university initiatives such as the AMS, the Leiden, Delft and Erasmus Rotterdam initiative (LDE), and Delft Deltas, Infrastructures & Mobility Initiative (DIMI) and the TP international academic network provide the department with excellent networks with large urbanized regions in the Netherlands as well as world-wide.

In general, the scientific staff of the TP department is highly qualified and motivated for both research and education. In order to further develop a culture for professional development, including in industry and research, we suggest that junior faculty members develop a career plan in consultation with senior faculty in their research areas. In addition, the department should encourage junior faculty members to increase their international exposure, which could be achieved through organizing and attending international conferences or sabbatical leaves in reputable universities or industry organizations.

5.5. Conclusion

We conclude that the research quality and viability of the TP department are commendable. Their contributions to a diverse range of topics in the field (including leveraging advanced technologies and emerging cross-cutting needs) have had sustained impact, and are characterized by quality, vitality and rigor. However, it does not appear that the department has done the appropriate SWOT analysis to identify their weaknesses and threats based on the view of stakeholders. Rather the strength and opportunities are being aligned to match the current capabilities and research interests of the department. The TP department is encouraged to utilize a more robust approach to developing the rationale for focus areas, and strengthen collaborations across the Faculty and across disciplines.

5.6. Overview of the quantitative assessment of the research unit

After having assessed the research quality, relevance to society and viability, and comparing that to the developments and standard in the field of Civil Engineering, we come to the following quantitative assessments:

Research quality:	excellent (1)
Relevance to society:	very good (2)
Viability :	excellent (1)



6. QUANTITATIVE AND QUALITATIVE ASSESSMENT OF THE DEPARTMENT OF WATER MANAGEMENT

6.1. Introduction

Treatment and transport of drinking water, wastewater and industrial water (the urban water cycle), as well as regional and global hydrologic cycles, are dominant themes in the Water Management research program. Water quality and extraction of raw materials, and water and energy transfer throughout the water cycle are focus areas as well. The department has a strong focus on droughts, precipitation, floods and how water behaves in the atmosphere and beneath and across the Earth's surface.

6.2. Research quality

TU Delft has long been known for excellence in Water Resources Research and this is well reflected today in outstanding publications of international impact, leadership in European and International research projects, destination for first-rate PhD students, international faculty sabbatical visitors from world leading research universities, invited seminars and research collaborations. This department has been particularly strong in maintaining a long-term view to fundamental excellence: it is asking the hard-scientific questions of societal importance and has a strong willingness to take the "path less travelled" in research to ultimately have path breaking and original advances in the understanding and design of cutting edge water engineering challenges. One significant indicator of success is the successful placement of graduates and post-doctoral associates in competitive junior faculty positions in programs around the world. The department has an outstanding practice of open searches for tenure track faculty, which allows new fresh ideas in research and education to be continually brought in. Not surprisingly, TU Delft enjoys rankings at the very top in the water community (ARWU #1), and a variety of rare and leading scholarships and medals of distinction have been awarded to colleagues in WM. Faculty are active in editing journals of significant standing in the broad community and are very present in leading professional societies.

Research is organized around: A. Observation and modelling of water resources; B. Water quality, treatment and reclamation; C. Urban water systems; and D. Monitoring and control of water processes. All the observational and experimental work is underpinned by a strong theoretical basis in hydrologic physics, water chemistry and environmental biology. The research is driven by a strong sense of anticipating future needs in water resources and driving best practices for sustainable development. As part of the research themes it is clear the department is pioneering new sensors, measurement techniques, satellite based remote sensing, data collection and transmission, visualization and control processes. Research in modelling, information systems and theory, and the formulation of governing equations, mathematical analysis, and the derivation of simplified models that capture the underlying processes is very much present and adds to the department's distinction and international reputation. The research is very relevant to the real world, which is under strong pressure to deliver sufficient water and ensure water quality. It carries out research in both Europe and emerging nations, including long standing links with Africa and Asia. Laboratories on campus are well coordinated, shared and the sense of an open community with generous scholarship and collegiality is quickly apparent. Students, staff and faculty members clearly interact across various domains and there is a long history and culture of sharing ideas and working across traditional domains.

The tenure track system at Delft has been well taken up in the Water Management department where many of the 'best practices' are already in place with open international recruitment, annual reviews, regular peer mentoring, emphasis on quality papers and assistance in grant preparation and a supportive environment for career development. There is significant room for improved start-up packages. The department is one where the community is driving the science and the community and leadership are able to take calculated risk in growing domains of interest. We think that further focus could be given to strengthen ground water research. Post-doctoral associates need to be prepared to move on in their careers and in WM there is, in general, a healthy understanding of the

dynamic life-cycle of academic research as well as the development needs of junior faculty members. There is a shared development of an integrated vision in the department (even though it has been historically loosely sub-divided into two areas – water quality and hydrology). Going forward it is planned to integrate these groups more strongly.

6.3. Relevance to society

Sustainable development goals

Naturally, Water Management (WM) is a strong contributor to SDG 6 (clean water and sanitation). We recognize that WM also pays attention to other SDGs on health, renewable energy, water infrastructure, sustainable cities, and responsible consumption and production. We strongly appreciate WM for its collaborations with the agricultural and food sector, its research on socio-hydrology, its open and inviting culture, and its strong international presence (particularly in Africa and Asia). Also, the new strategic direction on river clean-up is relevant and a promising field of research.

We are convinced that the impact of WM can grow even further in the research field of water and food, anaerobic treatment and circular thinking. We are impressed with the newly appointed faculty members and convinced they will pick up these and other challenges effectively. Another field to explore might be that of finance, especially if focused on realizing impact investments in water in developing countries.

Networks in society

WM is very well connected to society, both in The Netherlands as in developing countries. WM definitely uses its home market in the Netherlands to propel research, especially through its connections with industry. We would like to express our special appreciation for the activities in the Topsector Water and Maritime and the Urban Drainage Program. These connections are increasingly important, since NWO is requiring more and more co-funding.

WM combines strong networks in The Netherlands with relevant networks worldwide, especially in developing countries. We appreciate WMs use of technology such as remote sensing combined with citizen science to better understand water systems worldwide and put water on the political agenda. This type of research also creates possibilities for start-ups.

WM demonstrated several examples of its strategy to inform the general public, both aimed at children as well as adults. Its research appears on TV, in newspapers and journals and WM takes advantage of public events that are organized.

6.4. Viability

The most evident indication of vital long – term sustainability of the Department is reflected in the positive senior leadership and the junior tenure track faculty who are often budding super stars in their area of expertise, a fine distribution of PhDs, and the significant research areas of current focus. For instance, in urban water quality research topics includes important problems due to compounds of emerging chemicals, plastics, resource recovery and water treatment in an era with aging infrastructure. TU Delft is especially known for hydrology and water management work in Mozambique as well as west Africa under changing climate. The weather stations for Africa project will be highly visible internationally. The department is more networked than ever with the rest of CEG and across TU Delft. There was a very positive feeling in meeting the Assistant and Associate Professors, who felt confident thanks to fair guidance on the tenure track process, clear criteria, staff updates, student diversity, department seminars, and freedom to explore and build research in new fields and less traditional areas of expertise (e.g. Indian water reclamation projects). The teaching load is healthy and allows time for faculty, staff and students to be on the ground in international projects.



It is important for WM to be clearly visible to students in the Faculty. Earlier introduction of students to topics in WM in the degree programs would help. We are happy to see the Master in Environmental Engineering, which will increase visibility also.

A program such as WM that has a long history of success, may gradually be taken for granted, no longer be seen as current and/or critical, and loose support. This should be avoided at all costs. WM is and remains a vital part of TU Delft and a critical program in the Netherlands, and globally. WM should be front and centre in discussions around the future of Civil Engineering and also play a strong role in the Data Science and Computational domains at TU Delft. Our sense was that the leading faculty of WM are open to and interested in these challenges.

6.5. Conclusion

Water Management is integral to the long-term success of CEG and TU Delft with a vibrant history and a promising future. The people and their support are first-rate and TU Delft should move from strength to strength in the department of Water Management.

6.6. Overview of the quantitative assessment of the research unit

After having assessed the research quality, relevance to society and viability, and comparing that to the developments and standard in the field of Civil Engineering, we come to the following quantitative assessments:

Research quality:	excellent (1)
Relevance to society:	excellent (1)
Viability	excellency (1)

7. QUANTITATIVE AND QUALITATIVE ASSESSMENT OF THE DEPARTMENT OF STRUCTURAL ENGINEERING

7.1. Introduction

The focus of the research program of Structural Engineering (SE) is integrated, constructional design for civil infrastructure, constructional designs for buildings and new, sustainable or self-healing materials and their application in structures. The research program has an intertwined science, engineering and design approach and societal themes like durability and sustainability play an essential role.

At the time of the site visit, the new departments were only recently started, making it difficult to review their functioning. Therefore, we reviewed the research quality and relevance to society of the former, larger department and focused on the new departments when reviewing the viability.

7.2. Research quality

In contrast to the other departments, in which research can be divided into relatively clear subdomains, the research in SE is strongly heterogeneous. It includes mechanics, materials, building constructions, infrastructure systems and material-specific constructive solutions related to concrete, steel, bio-based materials and asphalt, and these topics are all interconnected. Notwithstanding this wide variety of research topics and more limited coherence within the department, very strong expertise has been established in, e.g., railway engineering, offshore wind infrastructure, computational engineering, but also self-healing asphalt or concrete. The activities in SE are based on the combination of expertise in mechanics, modelling, computational engineering, material science and specific fields like, for example, dynamic soil-structure-interaction or earthquake-engineering. In addition, the group Integral Design and Management is included in SE, embracing Integral Design, Engineering Asset Management, Engineering Project Management and Construction Technologies.

SE also plays a role in prototype development and testing of new innovative solutions for civil constructions and thus serves as a catalyst for the transfer of scientific insights into modern CE solutions. It provides the necessary scientific accompaniment for solutions, for which thorough investigations and predictions have to be carried out, in order to guarantee required safety standards in public spaces and economically sound sustainable solutions. To cope with this critical responsibility for society, SE has professional experimental facilities, technical staff and innovative scientists who are able to expertly handle theory, computational models, and risk assessments in combination with sustainable constructive solutions.

In its individual fields the department has a diverse group of researchers and chair holders. The department has world-class researchers and experts in specific fields with a very high visibility and excellent international links.

With the reorganization into two new departments, it became clear that a small number of research fields requires closer attention. These areas should be strengthened if they are considered worthwhile keeping. We recommend that the MT strongly supports the new department heads in this important task.

The current appointment strategy is suited to strengthen the group of researchers at the forefront of science. It aims to re-adjust the ratio between full-time professors and part-time professors from industry with a target of more than 70% full time researchers. By this re-adjustment the currently less favorable, but objectively positive typical indicators for performance will shift. SE is aware of the small proportion of female faculty. Recently hired tenure track professors reflect a more balanced ratio of 50/50, but it remains a critical point of attention as the cohort of female faculty members is far from critical mass.



It is recognized that the department's excellent lab facilities are crucial to cope with in its research mission and societal responsibility. The facilities are focused on mechanics, materials and constructions with interesting additional test-stands for dynamics. Experimental facilities for, for example, fire protection or building-physics are currently not included in CEG.

The department provides easy and uncomplicated access to the labs, also to junior faculty members. The integration of the facilities in the central building of CEG is ideal to guarantee a close connection with senior researchers, and to integrate experimental research and calibrations of numerical evaluations run by students and young researchers. The department's quality in the related theories and computational methodologies, supported by these world class labs, provides an excellent breeding ground for new and innovative constructive solutions.

We want to emphasize to the MT and the Executive Board, although they seem aware of this, the critical role of SE and the importance of its sound combination of experimental, application oriented and foundational research with services for society. We are concerned that this combination might systematically lead to a slightly negative impact on H-indices, which may hurt external funding if such indices are over-emphasized and over-valued.

7.3. Relevance to society

Sustainable development goals

The department clearly has an enormous responsibility for society. SE contributes to a broad variety of SDG's such as renewable energy, innovation and infrastructure, sustainable cities and communities, and responsible consumption and production. SE conducts research in all of these areas with a focus on materials and structures. We have a special appreciation for SE's research on new more sustainable materials and associated computational approaches, its research on existing structures and the preventive maintenance on pavements and railways, and its research on wind energy structures.

It can be challenging for SE to show evidence of its societal relevance to TU Delft and funding organizations as the common metrics used to measure success in research and valorization are not always optimally suited to SE's portfolio. We once again want to emphasize the critical national importance of the work done in SE with respect to safety and mobility (imagine the devastating impacts of large infrastructure failures) and we are concerned that this very important contribution may not be recognized and supported as deserved by the Central Board of the University.

We recommend that SE clearly formulates its research in terms of safety and security. We furthermore recommend that SE develops more cohesion in its organizational structure and its research themes to further increase impact. For example, SE and TP should work closely together and built collaborative research programs to address the huge challenge society faces in renovating its existing infrastructure.

The research on Integral Design needs to be strengthened and more strongly focused on the question of which design process in civil engineering generates maximum societal value. In answering this question new developments in the digital building process including digital construction and the use of VR, AI, big data, and/or the Internet of Things can be of great value.

Networks in society

SE is very well connected in the building chain, with public authorities such as the Railway and Highway authorities, consulting engineers, contractors and industry. This is for example reflected in joint research, part-time professors and patents. We are impressed with SE's European grants and the research done on highly critical and political topics as earthquakes caused by exploration of gas fields.

We recommend that SE extends its networks to enlarge its impact. We are convinced that a stronger departmental research vision will be of great help. We further recommend that TP and SE use the Dutch Top sector Logistic. For SE, the top sector High Tech Materials might also be interesting. SE already produces spin off companies, a result we highly value.

7.4. Viability

Most departments in the Faculty focus on current global challenges and *hot topics*, which holds the risk that highly relevant but currently less prominent issues are regarded as self-evident and thus might be undervalued. Several topics within the SE departments are traditionally well embedded in the societal value creation processes, but often in a less visible manner and not attracting the public's attention. We noticed that the SE department contains a collection of *research topics* that could not be easily incorporated in other departments.

We are glad with the decision to split the department SE in Engineering Structures (ES) and Materials, Mechanics, Management & Design (3Md). This readjustment will help to better structure the formerly very diverse SE department and also to balance the sizes of the departmental groups. The split of the related lab infrastructure between ES and 3Md is also good, as it addresses fundamentally different types of investigations. Whereas the merging of the cross-cutting topics Materials and Mechanics is apparent, the inclusion of the cross-cutting theme Management and Design is less evident. Thus, 3Md still seems to be heterogeneous and brings together loosely connected, less cohesive topics. The leaders of the two new departments are enthusiastic and very positive. They seem well aware of the potential challenges and weaknesses of the new departments and keen to address these.

It is understood that further cross-cutting themes that play an important role in CE-systems, like Building Information Modelling (BIM), societal evaluation and decision processes, the steering of the infrastructure's energy consumption, thermal and hygric building physics or risk control, are covered more intensively or even exclusively outside of CEG and ties to these external departments presumably depend on individual researchers, rather than on an overarching strategy. However, as these issues are related to traditional disciplines of CE, they would have a first natural link to SE. Given that the links between the individual departments inside CEG are less established as one would expect, we wonder (i) whether the potential of cross-fertilization of core themes in CE-relevant topics is optimally addressed in the research agendas at TU Delft, (ii) how cross-cutting fields relevant for CE can interact, respectively be included in the department CEG, and (iii) how the connection of the topics can be incentivized or supported. It is furthermore recommended to discuss how the strategic development of current and further cross-cutting themes can include ethics, political/social sciences and possibly a strengthening of BIM. Together with the topic Management and Design they could be considered *in the core of* the Faculty with strong interaction to all departments.

7.5. Conclusion

Our comments and suggestions made above should not be misunderstood as criticism. They are meant to be constructive, also regarding the transition that has been initiated anyhow. We are deeply impressed with SE's high quality and world class research, and its dedication to education, and its collaborative atmosphere. The current transition to new departments is a wise move.

7.6. Overview of the quantitative assessment of the research unit

After having assessed the research quality, relevance to society and viability, and comparing that to the developments and standard in the field of Civil Engineering, we come to the following quantitative assessments:

Research quality:	very good (2)
Relevance to society:	very good (2)
Viability	very good (2)



APPENDICES





APPENDIX 1: THE SEP CRITERIA AND CATEGORIES

There are three criteria that have to be assessed.

- Research quality:
 - Level of excellence in the international field;
 - Quality and Scientific relevance of research;
 - Contribution to body of scientific knowledge;
 - Academic reputation;
 - Scale of the unit's research results (scientific publications, instruments and infrastructure developed and other contributions).

- Relevance to society:
 - quality, scale and relevance of contributions targeting specific economic, social or cultural target groups;
 - advisory reports for policy;
 - contributions to public debates.

The point is to assess contributions in areas that the research unit has itself designated as target areas.

- Viability:
 - the strategy that the research unit intends to pursue in the years ahead and the extent to which it is capable of meeting its targets in research and society during this period;
 - the governance and leadership skills of the research unit's management.

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

APPENDIX 2: CURRICULA VITAE OF THE COMMITTEE MEMBERS

Professor Margot Gerritsen (chair) was born and raised in the Netherlands. After completion of her Master's degree in Applied Mathematics she spend time in various places in Northern Europe, and the US. Gerritsen received her PhD at Stanford after which she took a position as a faculty member of the Department of Engineering Sciences at the University of Auckland (New Zealand). In 2001 she returned to Stanford University where Gerritsen is now professor in Energy Resources Engineering. Her research interests are computer simulation and mathematical analysis of engineering processes. She is furthermore director of ICME, the institute for Computational and Mathematical Engineering and the Senior Associate dean for Education Initiatives in the School of Earth, Energy & Environmental Sciences. Gerritsen is specialized in the development of computational methods for renewable and fossil energy production. She is active in coastal open dynamics and yacht design, as well as several other areas in computational mathematics. Apart from research, Gerritsen enjoys teaching in the ERE department and in ICME. She also teaches a Stanford ESF course.

Professor Marc Parlange is the Provost and Senior Vice-President of Monash University and is Professor in the Department of Civil Engineering. Prior to his appointment at Monash in 2017, Professor Parlange was Dean of the Faculty of Applied Science at the University of British Columbia (Canada). He served as Dean of the School of Architecture, Civil and Environmental Engineering (2008 - 2013) and Director of the Institute of Environmental Engineering (2004 - 2007) at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He has also been a professor and department chair at Johns Hopkins University as well as Assistant and Associate Professor at the University of California at Davis. He has a Master of Science and PhD from Cornell University and a Bachelor of Science degree from Griffith University. Professor Parlange is recognized internationally for his expertise in environmental fluid mechanics. His contributions in this broad area primarily relate to the measurement and simulation of air and water flows over complex terrain, with a focus on how air turbulence and atmospheric dynamics (atmospheric boundary layer flow) influence urban, agricultural and alpine environments. Professor Parlange is active in addressing water resources challenges and environmental change in remote communities, particularly West Africa, through his research on hydrology and climate change.

Professor Joannes Westerink is Joseph and Nona Ahearn Professor in Computational Science and Engineering at the Department of Civil & Environmental Engineering & Earth Sciences of the University of Notre Dame. He is a concurrent professor in the Department of Computer Science and Engineering, Department of Aerospace and Mechanical Engineering, and the Department of Applied and Computational Mathematics and Statistics. Westerink earned his bachelors and masters in Civil Engineering at the State University of New York at Buffalo and subsequently his PhD at the Massachusetts Institute of Technology. He was research assistant at the State University of New York at Buffalo and Massachusetts Institute of Technology and assistant professor at Princeton University and Texas A&M University before going to the University of Notre Dame where he was assistant, associate, and full professor and at present chaired professor. Westerink's research interests are computational fluid mechanics, finite elements, circulation and transport in coastal seas and oceans, tidal hydrodynamics, hurricane storm surge prediction, geophysical turbulence, and convection-diffusion. He is co-developer of the widely used ADCIRC coastal hydrodynamics software used in analyzing and forecasting tides and hurricane storm surge worldwide and in the US by the USACE, NOAA, FEMA, the NRC, and private sector companies.

Professor William H.K. Lam is a Chair Professor of Civil and Transportation Engineering and Head of the Department of Civil and Environmental Engineering (CEE) at The Hong Kong Polytechnic University (PolyU), P.R. China. He joined the PolyU as lecturer in 1983 and has been promoted to Chair Professor in 2003. He has also been appointed as the Associate Head of CEE in 2007 and then the Head of CEE in 2013. Professor Lam is currently the President of the Hong Kong Society for Transportation Studies (HKSTS) and the Past Chairman of Logistics and Transportation Division of



the Hong Kong Institution of Engineers (HKIE). He is also the Past Chairman of HKIE Civil Division in 2003 and Chairman of HKIE Civil Discipline Advisory Panel from 2008-2011. He has been appointed as Chiang Jiang Chair Professor at the Beijing Jiaotong University for the period from 2010 to 2013. In 2011, Lam and his colleagues from Beijing Jiaotong University, Beihang University, and the Hong Kong University of Science and Technology 2 were granted with the National Natural Science Award, the highest honor in China. Recently, he has been appointed as Honorary Professor at the Institute for Transport and Logistics Studies, The University of Sydney.

Professor Gerhard Müller studied civil engineering at TUM, after which he obtained his doctorate in 1989. He did his lecturer qualification in engineering mechanics (1993). From 1992 to 2004, he worked at a large engineering firm. While there, he was involved in all aspects of sound installation and vibration control as well as air pollution control. Covering a wide range of engineering disciplines, he managed the company for nine years. Müller is President of the European Association for Structural Dynamics (EASD). In 2009/10, he was Chairman of the Association for Civil Engineering and Geodesy (FTBG) and the umbrella association of Faculty Associations for Engineering and Computer Science (4ING e.V.). Müller is Chairman of the Education Committee of the Bavarian Chamber of Engineers – Civil and is actively involved in the Cusanuswerk Catholic scholarship body. Müller conducts research into structural dynamics and vibroacoustics. This covers vibrations and their interactions and the radiation of air-borne or structure-borne sound. Problems are examined at different scales in the low, mid and high frequency ranges. In the low-frequency range, typical for structural dynamics, the Chair's researchers examine the dynamic soil-structure interaction by applying hybrid approaches. These combine simple analytic studies that are closely connected to the physical phenomena with current numerical models. In the mid and high frequency range, which is relevant for sound radiation within structures, statistical approaches are also used. A special focus is placed on modelling realistic boundary conditions, as they would occur in buildings or vehicles.

Ir. Karin Sluis studied civil engineering at TUD. After graduation in Fluid Mechanics she started her career at Witteveen+Bos Consulting Engineers, active amongst others in the fields of deltatechnology, water, infrastructure and mobility. She has had several roles within the company, such as business unit manager Traffic&Roads and business line manager Built Environment. Since 2013 she is Managing Director of Witteveen+Bos. Next to this main position Karin is member of the so called Topteam of the Topsector Water and Maritime, in which she represents the Dutch Association of Consulting Engineers. She is also member of the supervisory board of Saxion University of Applied Science.



APPENDIX 3: PROGRAMME OF THE SITE VISIT

Sunday 4 February 2018

16:00	19:00	Kick-off meeting committee and secretary only <ul style="list-style-type: none"> - Introduction protocol (SEP) - Specifics on Dutch research (organization, finances, cultural habits, PhD candidates) - Preliminary findings/observations - Preparation of the interviews
19:00	19:30	Welcome by Dean and introduction of Heads of Department
19:30	21:30	Dinner

Monday 5 February 2018

08:30	09:00	Arrival and preparation committee
09:00	10:00	Meeting with Faculty Management on general topics
10:00	10:15	break
10:15	11:00	Interview department head Hydraulic Engineering
11:00	11:15	break
11:15	12:00	Interview department head Transport and Planning
12:00	12:45	Lunch
12:45	13:30	Interview department head Water Management
13:30	13:45	break
13:45	14:30	Interview department heads Structural Engineering
14:30	14:45	break
14:45	15:15	Interview assistant/associate professors Hydraulic Engineering
15:15	15:30	break
15:30	16:15	Interview research school TRAIL
16:15	18:30	Visit to the labs and facilities of the four departments

Tuesday 6 February 2018

08:30	09:00	Preparation committee and secretary
09:00	09:30	Interview assistant/associate professors Water Management
09:30	10:00	Interview assistant/associate professors Structural Engineering
10:00	10:15	break
10:15	10:45	Interview with selection postdocs
10:45	11:00	break
11:00	11:45	Interview with PhD students
11:45	12:30	Interview with management graduate school
12:30	13:15	Lunch
13:15	13:45	Interview assistant/associate professors Transport and Planning
13:45	14:00	break
14:00	15:15	Discussing preliminary findings by committee
15:15	15:45	Final interview dean and department heads
15:45	16:45	Preliminary scores, preparing for presentation and initial writing session.
16:45	17:00	Oral presentation preliminary findings by chair





APPENDIX 4: QUANTITATIVE DATA

Funding of Civil Engineering (4 departments combined)

	2011		2012		2013		2014		2015		2016	
<i>Funding:</i>												
Direct funding (1)	15.274	47%	13.750	41%	14.957	45%	16.190	45%	17.656	47%	19.664	51%
Research grants (2)	1.109	3%	3.026	9%	4.558	14%	4.765	13%	4.837	13%	5.456	14%
Contract research (3)	15.132	46%	16.247	49%	13.367	40%	13.940	39%	13.970	37%	13.158	34%
Other (4)	1.050	3%	387	1%	529	2%	1.030	3%	1.110	3%	657	2%
Total funding	32.565	100%	33.410	100%	33.411	100%	35.925	100%	37.573	100%	38.936	100%
<i>Expenditure:</i>												
Personnel costs	24.165	75%	24.663	73%	25.370	75%	27.982	77%	29.624	79%	30.626	80%
Other costs	7.885	25%	8.978	27%	8.583	25%	8.497	23%	7.979	21%	7.841	20%
Total Expenditure	32.050	100%	33.641	100%	33.953	100%	36.478	100%	37.603	100%	38.467	100%

Note 1: Direct funding (basisfinanciering / lump-sum budget)

Note 2: Research grants obtained in national scientific competition (e.g. grants from NWO and the Royal Academy)

Note 3: Research contracts for specific research projects obtained from external organizations, such as industry, government ministries, European organizations and charitable organizations

Note 4: Funds that do not fit into the other categories

Hydraulic Engineering

	2011		2012		2013		2014		2015		2016	
<i>Funding:</i>												
Direct funding (1)	3.494	56%	3.202	47%	3.387	52%	3.467	48%	4.278	55%	4.656	52%
Research grants (2)	146	2%	298	4%	1.199	18%	1.147	16%	1.430	18%	2.199	25%
Contract research (3)	2.380	38%	3.213	47%	1.671	26%	2.419	34%	1.888	24%	1.892	21%
Other (4)	260	4%	101	1%	281	4%	159	2%	195	3%	147	2%
Total funding	6.280	100%	6.814	100%	6.538	100%	7.193	100%	7.791	100%	8.893	100%
<i>Expenditure:</i>												
Personnel costs	5.032	75%	5.262	74%	5.532	80%	5.648	79%	6.147	79%	7.117	80%
Other costs	1.644	25%	1.838	26%	1.396	20%	1.516	21%	1.664	21%	1.754	20%
Total Expenditure	6.676	100%	7.100	100%	6.928	100%	7.164	100%	7.811	100%	8.872	100%

Structural Engineering

	2011		2012		2013		2014		2015		2016	
<i>Funding:</i>												
Direct funding (1)	6.095	46%	5.349	40%	5.899	43%	6.489	42%	7.270	43%	8.618	50%
Research grants (2)	541	4%	1.505	11%	1.927	14%	1.691	11%	1.680	10%	883	5%
Contract research (3)	6.357	48%	6.604	49%	5.955	43%	6.822	45%	7.799	46%	7.875	45%
Other (4)	309	2%	-14	0%	30	0%	320	2%	42	0%	-50	0%
Total funding	13.302	100%	13.444	100%	13.811	100%	15.322	100%	16.791	100%	17.326	100%
<i>Expenditure:</i>												
Personnel costs	10.242	76%	10.104	74%	10.252	71%	11.839	73%	13.124	79%	13.180	77%
Other costs	3.226	24%	3.576	26%	4.132	29%	4.323	27%	3.457	21%	3.856	23%
Total Expenditure	13.468	100%	13.680	100%	14.384	100%	16.161	100%	16.581	100%	17.036	100%



Water Management

	2011		2012		2013		2014		2015		2016	
<i>Funding:</i>												
Direct funding (1)	3.551	41%	3.119	37%	3.399	43%	3.879	48%	3.747	49%	3.806	52%
Research grants (2)	85	1%	510	6%	643	8%	1.006	12%	835	11%	1.338	18%
Contract research (3)	4.838	56%	4.848	57%	3.762	48%	2.968	36%	2.604	34%	1.798	25%
Other (4)	236	3%	38	0%	52	1%	280	3%	430	6%	363	5%
Total funding	8.710	100%	8.515	100%	7.856	100%	8.134	100%	7.616	100%	7.305	100%
<i>Expenditure:</i>												
Personnel costs	5.553	71%	5.785	70%	5.726	74%	5.999	77%	6.000	77%	5.638	78%
Other costs	2.254	29%	2.527	30%	1.994	26%	1.767	23%	1.770	23%	1.547	22%
Total Expenditure	7.807	100%	8.312	100%	7.720	100%	7.765	100%	7.770	100%	7.185	100%

Transport & Planning

	2011		2012		2013		2014		2015		2016	
<i>Funding:</i>												
Direct funding (1)	2.134	50%	2.080	45%	2.272	44%	2.355	45%	2.360	44%	2.585	48%
Research grants (2)	337	8%	714	15%	789	15%	921	17%	892	17%	1.036	19%
Contract research (3)	1.557	36%	1.581	34%	1.979	38%	1.730	33%	1.679	31%	1.594	29%
Other (4)	245	6%	262	6%	166	3%	271	5%	444	8%	197	4%
Total funding	4.273	100%	4.637	100%	5.206	100%	5.277	100%	5.374	100%	5.412	100%
<i>Expenditure:</i>												
Personnel costs	3.338	81%	3.512	77%	3.860	78%	4.497	83%	4.353	80%	4.690	87%
Other costs	761	19%	1.037	23%	1.061	22%	892	17%	1.088	20%	684	13%
Total Expenditure	4.099	100%	4.549	100%	4.921	100%	5.388	100%	5.441	100%	5.375	100%



Research staff – 4 research units aggregated

	2011		2012		2013		2014		2015		2016	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff (1)	159	43,5	164	45,4	171	46,2	174	47,6	174	48,2	178	50,2
Researchers (2)	129	47,3	132	46,7	148	53,2	192	72,3	197	81,3	255	103,3
PhD candidates (3)	399	233,8	422	260,1	435	267,7	457	269,3	464	264,4	480	279,5
Total Research staff	687	324,5	718	352,2	754	367,1	823	389,1	835	394,0	913	433,0
Support staff	25	12,6	25	12,4	28	12,7	35	13,9	31	14,7	32	17,2
Total staff	712	337,1	743	364,6	782	379,8	858	403,1	866	408,6	945	450,2

(1) comparable with WOPI category HGL, UHD and UD, tenured and non-tenured)

(2) includes post-docs and temporary 'onderzoekers'

(3) includes all PhD categories

Hydraulic Engineering	2011		2012		2013		2014		2015		2016	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff (1)	36	7,1	35	7,4	38	7,6	40	9,7	41	10,3	44	10,5
Researchers (2)	35	11,7	38	13,3	50	17,3	57	18,8	51	16,5	63	21,6
PhD candidates (3)	103	62,0	105	67,5	113	66,3	123	66,7	115	63,3	116	68,9
Total Research staff	174	80,8	178	88,1	201	91,2	220	95,2	207	90,1	223	101,0
Support staff	6	3,1	6	3,1	6	2,6	6	2,3	4	2,2	5	2,8
Total staff	180	83,9	184	91,2	207	93,8	226	97,5	211	92,3	228	103,8

Structural Engineering	2011		2012		2013		2014		2015		2016	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff (1)	52	18,6	53	17,8	56	17,4	56	17,8	59	17,7	59	18,9
Researchers (2)	50	17,1	45	18,9	50	22,2	73	31,4	94	42,9	122	52,1
PhD candidates (3)	136	80,1	138	87,7	134	92,5	139	91,8	146	94,1	139	89,4
Total Research staff	238	115,9	236	124,3	240	132,2	268	141,0	299	154,7	320	160,4
Support staff	16	9,0	17	9,1	16	9,2	17	9,4	19	10,6	20	12,1
Total staff	254	124,9	253	133,4	256	141,4	285	150,4	318	165,4	340	172,4

Transport & Planning	2011		2012		2013		2014		2015		2016	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff (1)	30	8,9	34	10,1	34	10,3	36	9,4	32	9,2	32	9,6
Researchers (2)	14	6,2	17	7,2	13	6,4	15	7,7	14	5,4	17	7,3
PhD candidates (3)	34	19,0	38	21,5	37	21,3	43	21,7	49	24,1	62	34,7
Total Research staff	78	34,1	89	38,8	84	38,1	94	38,9	95	38,8	111	51,6
Support staff	1	0,3	0	0,0	0	0,0	1	0,7	2	1,0	3	1,5
Total staff	79	34,4	89	38,8	84	38,1	95	39,6	97	39,7	114	53,0

Water Management	2011		2012		2013		2014		2015		2016	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff (1)	41	8,9	42	10,2	43	10,8	42	10,7	42	10,9	43	11,3
Researchers (2)	30	12,2	32	7,4	35	7,3	47	14,4	38	16,5	53	22,3
PhD candidates (3)	126	72,7	141	83,4	151	87,5	152	89,1	154	82,9	163	86,5
Total Research staff	197	93,7	215	100,9	229	105,6	241	114,1	234	110,4	259	120,1
Support staff	2	0,2	2	0,2	6	0,9	11	1,5	6	0,9	4	0,8
Total staff	199	93,9	217	101,1	235	106,5	252	115,6	240	111,2	263	121,0

Research output

Hydraulic Engineering	2011	2012	2013	2014	2015	2016
Refereed articles	64	74	91	71	97	127
Non-refereed articles (1)	0	1	0	2	2	1
Books	0	3	0	0	0	0
Book chapters	11	6	2	8	4	4
PhD theses	7	13	18	18	14	16
Conference papers	119	141	92	77	68	49
Professional publications (2)	16	21	20	14	22	14
Other research output (3)	48	76	169	144	106	74
Total publications	265	335	392	334	313	285

Structural Engineering	2011	2012	2013	2014	2015	2016
Refereed articles	92	130	125	119	114	184
Non-refereed articles (1)	7	0	1	0	2	2
Books	1	1	4	3	0	1
Book chapters	9	7	13	13	12	3
PhD theses	16	13	18	11	22	14
Conference papers	159	189	181	178	133	152
Professional publications (2)	33	56	32	32	22	27
Other research output (3)	39	44	133	61	111	64
Total publications	356	440	507	417	416	447

Transport & Planning	2011	2012	2013	2014	2015	2016
Refereed articles	31	36	34	52	71	97
Non-refereed articles (1)	1	0	1	0	3	0
Books	1	1	1	0	1	2
Book chapters	3	7	3	8	11	5
PhD theses	4	1	7	4	2	8
Conference papers	82	95	79	91	95	59
Professional publications (2)	33	14	36	42	35	21
Other research output (3)	17	40	121	124	151	159
Total publications	172	194	282	321	369	351

Water Management	2011	2012	2013	2014	2015	2016
Refereed articles	135	152	147	180	160	154
Non-refereed articles (1)	9	2	2	2	1	8
Books	1	3	0	0	0	1
Book chapters	8	9	6	7	5	2
PhD theses	17	13	17	21	22	20
Conference papers	91	77	43	52	26	18
Professional publications (2)	23	30	35	18	10	6
Other research output (3)	100	75	185	226	175	133
Total publications	384	361	435	506	399	342



APPENDIX 5: REVIEW OF TRAIL RESEARCH SCHOOL

TRAIL is the Netherlands Research School on Transport, Infrastructure and Logistics. TRAIL trains PhD candidates and performs scientific and applied scientific research in the fields of mobility, transport, logistics, traffic, infrastructure and transport systems. TRAIL is a collaborative initiative of six Dutch universities and is accredited as research school since 1997. TRAIL has a Programme Board, an Advisory Board, and a PhD council. It is run by the TRAIL bureau.

The review of TRAIL Research School was part of the research review in Civil Engineering of the TU Delft. The review committee was informed about the objective, activities and evaluation results of TRAIL. In addition to written input, the committee interviewed the Scientific director and the Managing Director of TRAIL. The committee was provided with a short description of TRAIL, its results over the period 2013-2016 and (quantitative) information on members, PhD students and courses.

Objective of TRAIL is to help train and educate PhD candidates, to support efficient and high quality collaboration across the six participating universities and to provide and support community building. Academic staff can become TRAIL member if they fulfil criteria related to being 1) Available for teaching, 2) supervising PhD students and 3) publishing in peer reviewed, academic journals and publishing reviewed book chapters. If the supervisor of a PhD candidate is TRAIL member, the PhD student is eligible for participation and training. Participating Faculties all pay a yearly fixed fee to finance TRAIL, which adds up to a total budget of 200.000 EUR/year. PhD candidates do not have to pay a fee for courses they follow. Total budget was reduced by approximately 50% in the past period, which makes it important for TRAIL to find a balance between efficiency and quality. The external advisory board was discontinued for this reason. The input from external stakeholders, e.g. industry and businesses, is now obtained via TRAIL members.

TRAIL organises the PhD training in close collaboration with the local Graduate Schools. With the professionalisation of the local Graduate Schools, a number of changes took place in the past period. Most noticeable change is the division of generic and disciplinary courses. TRAIL reduced the number of generic courses, which are now part of most local Graduate Schools. TRAIL predominantly focuses on disciplinary courses and training. As an example, the Delft Graduate School requires that its PhD candidates obtain 15 credits in disciplinary courses. For PhD candidates in transport, these 15 credits are obtained via TRAIL. The contacts between TRAIL and the local Graduate Schools seem good, both sides clearly value the collaboration.

Core activities of TRAIL are the organisation of disciplinary courses (on average 10 courses per year), the organisation of seminars, informal activities for community building and once a year a conference is organised. During this conferences all PhD students can present their research plan, research results or publication.

Courses are specifically designed for TRAIL PhD candidates. The quality of the courses is regularly evaluated and overall PhD candidates are very positive about the courses. Suggestions for improvements, and lecturers who do not perform well are dealt with in a professional manner. The committee discussed the disciplinary field that is covered by the courses that are provided. For example, infrastructure is not explicitly part of a course, but is integrated in a number of courses. New courses are usually developed if sufficient PhD candidates are requesting a course on a certain topic. The committee understands that a minimum number of PhD candidates should be participating in a course, but at the same time recommends TRAIL to look into possibilities for courses on topics that are relevant for the discipline, but not meet the required number of participants. For example, courses can be provided once every two years. Another possibility might be to consider monetizing the courses, in order to gain funding to subsequently provide courses for smaller groups of PhD candidates.

The evaluation of individual courses is well organized. In addition, PhD candidates are required to fill out a form on the entire programme prior to their PhD defence. The committee considers that it would be interesting to analyse the value of TRAIL in respect to duration of the PhD and drop-out

percentages of PhD candidates. It would certainly strengthen the position of TRAIL (and other national research schools) to be able to show added value to local graduate schools.

In the previous review report a number of minor remarks were provided, relating to bringing together the multiple TIL-disciplines within TRAIL and the positions of TRAIL PhD candidates in the overall training of PhD candidates.

The committee verified that the relation between TRAIL and the local Graduate Schools has been improved and seems to function very well. Also the collaboration of different disciplines in the courses is adequate.

The committee concludes that in the past period TRAIL has continued providing high quality courses to PhD candidates as well as provided community building. Issues that were mentioned in the previous report were responded to adequately. The committee is very impressed by TRAIL and considers that national research schools are a strong aspect of training young scientists in the Netherlands.

