

# **RESEARCH REVIEW**

SCHOOL OF INDUSTRIAL ENGINEERING

SCHOOL OF INNOVATION SCIENCES

**EINDHOVEN UNIVERSITY OF TECHNOLOGY**

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# REPORT ON THE RESEARCH REVIEW OF THE SCHOOL OF INDUSTRIAL ENGINEERING AND THE SCHOOL OF INNOVATION SCIENCES OF EINDHOVEN UNIVERSITY OF TECHNOLOGY

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# 1. FOREWORD BY COMMITTEE CHAIR

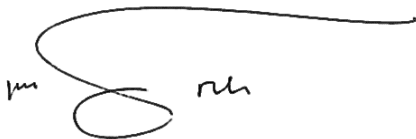
This is a rather particular assessment report in so far as it pulls together the review of two different schools: the School of Industrial Engineering and the School of Innovation Sciences, comprising together the Department of Industrial Engineering and Innovation Sciences of Eindhoven University of Technology.

As a result, the research themes covered by the two schools include a wide diversity of topics: from Human Performance Management to Human-Technology Interaction; from Information Systems to Operations, Planning, Accounting and Control; from Innovation, Technology, Entrepreneurship and Marketing to Technology, Innovation and Society; and last but not least Philosophy and Ethics. It was not easy to find a review committee with a sufficiently broad research coverage and interest to cover the full diversity of research topics being carried out at the TU/e's Department of Industrial Engineering and Innovation Sciences (IE&IS). In the end though, an excellent, world class team of highly respected and motivated experts was brought together, interestingly enough composed only of foreign, non-Dutch nationals whom I had the privilege to chair. I'm particularly grateful to all members of the review committee for their openness and readiness to become involved over two long days in detailed discussions on topics and methodologies in a wide array of disciplines.

The quality of our discussions was in a certain way witness to the many challenges posed by multi-disciplinary research in the fields of industrial engineering and innovation sciences. The two schools also seem to provide an intellectually challenging and organisationally effective research environment within the one Department of IE&IS. And while as external experts we are always tempted to challenge the particular organisational set-up with in this case: the two schools, two self-assessment reports, two vice-deans, two PhD programmes, etc., the members of the committee gradually became convinced that this particular organisational set-up was appropriate to let the different themes develop their own research reputation and dynamics.

Given the Standard Evaluation Protocol 2015-2021 (SEP) for research reviews in the Netherlands, the committee was not allowed to provide different assessments on the quality, relevance to society and viability of the scientific research of the research groups within the two Schools, only at the average level of both Schools together. Overall the committee was particularly impressed with the quality, relevance and viability of the research at both Schools, which was graded as "very good". At the more detailed research level, the committee has also identified a number of excellent, world-class research fields within both Schools.

On behalf of all committee members, I would like to thank in particular the Dean of the Department, Prof. Ingrid Heynderickx, for her openness and readiness to respond to our queries; and to all the academic and administrative staff at the Department of IE&IS for the particularly pleasant and transparent way in which we could discuss its research performance.

A handwritten signature in black ink, appearing to read 'Luc Soete', with a long horizontal flourish extending to the right.

Professor Luc Soete,  
Chair of the review committee



## 2. THE REVIEW COMMITTEE AND THE PROCEDURES

### 2.1. SCOPE OF THE REVIEW

The review committee Industrial Engineering and Innovation Sciences was asked to perform a review of the research conducted in the School of Industrial Engineering (School IE) and the School of Innovation Sciences (School IS). The two schools are the research units within the Department of Industrial Engineering and Innovation Sciences of Eindhoven University of Technology. The review covers the following research groups:

#### School IE

- Human Performance Management (HPM)
- Information Systems (IS)
- Innovation, Technology, Entrepreneurship and Marketing (ITEM)
- Operations, Planning, Accounting and Control (OPAC)

#### School IS

- Human-Technology Interaction (HTI)
- Philosophy and Ethics (PE)
- Technology, Innovation and Society (TIS)

In accordance with the Standard Evaluation Protocol 2015-2021 (SEP) for research reviews in the Netherlands, the committee's tasks were to assess the quality, relevance to society and viability of the scientific research at both research units, as well as the strategic targets and extent to which the Schools are equipped to achieve these targets. A qualitative review of the PhD training programme, research integrity policy and diversity also formed part of the committee's assignment. In the Terms of Reference (ToR), the committee was asked to pay attention to the longer-term strategy of the Department, given the disciplines and expertise present, and to compare the Department to equivalent departments (i.e., the home institutes of the committee members). The assessments should therefore be interpreted from this comparative perspective.

### 2.2. COMPOSITION OF THE COMMITTEE

The composition of the committee was as follows:

- Prof. L.L.G. Soete, Maastricht University, the Netherlands;
- Prof. G. Grote, ETH Zürich, Switzerland;
- Prof. T.A. Runkler, Siemens & Technical University, Munich, Germany;
- Prof. S. Salomo, Technical University of Denmark, Denmark;
- Prof. C.Y. Lee, Hong Kong University of Science & Technology, Hong Kong;
- Prof. T. Hartig, Uppsala University, Sweden;
- Prof. S.O. Hansson, Royal Institute of Technology, Sweden;
- Prof. D. Foray, EPFL, Switzerland.

The curricula vitae of the committee members are included in Appendix 2.

The committee was supported by Dr. Erwin van Rijswoud, who acted as secretary on behalf of QANU.



## 2.3. INDEPENDENCE

All members of the committee signed a statement of independence to safeguard that they would assess the quality of School IE and School IS of the Eindhoven University of Technology in an unbiased and independent way. Any existing personal or professional relationships between committee members and the research unit(s) under review were reported and discussed in the first committee meeting. The committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

## 2.4. DATA PROVIDED TO THE COMMITTEE

The committee received two self-evaluation reports from the units under review, including all the information required by the SEP.

The committee also received the following documents:

- the Terms of Reference;
- the SEP 2015-2021;
- lists of publications, consisting of five scientific key publications per School, and another five scientific key publications and if possible societal key publications for each of the seven research groups.

During the site visit, further data was provided by the Schools:

- The University's tenure track policy, including the data on the progress of tenure track staff (2010-2017);
- Slides of poster presentations by PhD candidates (two per research group);
- An additional presentation (including slides) by the Dean on the research themes and research policy.

## 2.5. PROCEDURES FOLLOWED BY THE COMMITTEE

The committee proceeded according to the SEP. Prior to the first meeting, all committee members independently formulated a preliminary assessment of the units under review based on the written information that was provided prior to the site visit. The final report is based not only on the documentation provided by the research units, but also includes the information gathered during the interviews with management and representatives of the research units. The interviews took place on 9-10 May 2017 in Eindhoven (see the schedule in Appendix 3).

Preceding the interviews, the committee was briefed by QANU about research reviews according to the SEP. It also discussed the preliminary assessments, decided upon a number of comments and questions, and agreed upon procedural matters and aspects of the review. After the interviews the committee discussed its findings and comments, allowing the chair to present the preliminary findings and the secretary to draft a first version of the review report.

The draft report was presented to the research units concerned for factual corrections and comments. In close consultation with the chair and other committee members, the comments were reviewed by the secretary and incorporated in the final report. The final report was presented to the Board of the University and to the management of the research units.

The committee used the criteria and categories of the Standard Evaluation Protocol 2015-2021 (SEP). For more information see Appendix 1.



## 2.6. STRUCTURE OF THE REPORT

The findings in this report reflect the considerations, assessment and internal discussions on how to interpret the different descriptors proposed within the SEP and apply them to the different themes within each of the two schools. Ultimately, the findings as reported here reflect the consensus amongst committee members. In discussing the request to have the same committee review two schools in the same Department, the committee believed it was suited to focus its assessment at different levels of aggregation.

As evidenced in the two self-assessment reports, aspects of strategy, leadership and viability are closely related to the Department's policy, with only minor differences in how this is being operationalized at the School level. In effect, the research strategies of the Department and Schools reflect the viability of both Schools. They sketch the ways in which the Department is planning its research and how it is responding to external developments. Viability is viewed by the committee as the effects of this strategy on the quality and sustainability of the Department and the Schools. The committee thus discusses the strategy and viability at the Department level, with an identical assessment for the two Schools (chapter 4).

The same goes for aspects of the PhD programs, integrity and data management, and diversity (chapters 7-9): these assessments are discussed in integrated chapters for each topic, albeit with more specific comments for each School.

In effect, what will be explicitly discussed separately at the School level are research quality and relevance to society (chapters 5 and 6). These chapters also contain brief discussions of their respective research groups, although the assessment as such concerns the Schools as a whole, and not the performances of individual groups.



### 3. SUMMARY JUDGMENT

The committee has reviewed the School of Industrial Engineering and the School of Innovation Sciences according to the SEP protocol (2015-2021). The two Schools are the research units within the Department of Industrial Engineering and Innovation Sciences of Eindhoven University of Technology. The Schools are assessed on research quality, societal relevance and viability; as well as on their PhD programmes, research integrity policy and data management, and diversity. As some aspects of the Schools are organized collectively at Departmental level, the committee decided to assess viability, the PhD programmes, research integrity policy and data management, and diversity at the level of the Department. Research quality and societal relevance are assessed on the level of the Schools.

#### *Viability*

The committee assessed viability of the Schools and the Department as a matter of how well the strategic choices of the management of the Schools and Department respond to the external developments, and what influence this will have on the quality and sustainability of the Department and its Schools. Aspects the committee reviewed are the research targets, disciplinary and interdisciplinary research, the tenure track policy, the teaching load and staff mobility. The committee believes the Schools have the challenges in these areas in clear view, and is responding to them in responsible and adequate manner. An essential feature of the Department's viability is the research theme policy. In the research theme policy the Department is developing, highly relevant topics have been formulated as focal points for interdisciplinary cooperation, and researchers from both Schools are already participating in joint projects. The committee agrees with the way in which the Department's financial resources are being used to strengthen the research themes, for example by creating PhD schemes and appointing project development officers. The research theme policy therefore is a very good response to past challenges (e.g., a strain on research output because of high teaching loads), a means to further increase the cooperation between research groups, and a very good strategy to further stimulate the quality and relevance of the Schools and Department.

#### **School of Industrial Engineering**

##### *Research quality*

The School produces well-cited, influential and internationally recognized research. The articles the committee reviewed are rigorous, thorough and productive in application. The publications, analytic techniques, questionnaires and so forth that are developed by the Schools used by peers, and the provided examples show a very good ability to set standards in the respective research domain, and add to the overall research portfolio. The School has had increasing success in obtaining competitive funding, and is strong in acquiring research funding in collaboration with industry. The committee recommends to increase efforts in obtaining European funding. The PhD and PDEng schemes are also performing well, and the Schools aspiration to increase the number of PhD's is welcomed by the committee.

##### *Societal relevance*

The School is very good at combining classical engineering approaches with real life industry problems. With this good and pragmatic strategy, the School is securing adequate means for converting research results into solutions, as evidenced by the amount of grant money that has come from industry and third parties. To date, societal relevance is mainly created at the level of the specific, excellent projects and by individual and prominent researchers. Given the research power and close industry ties of TU/e as a whole and the integral and socio-technical nature of the strategic challenges TU/e has defined for itself, there is still a substantial, unrealized potential for the School IE to be relevant to society and industry. The committee thus concludes that in order to further develop, the Department as a whole should continue with the research theme policy and pursue a more explicit, specific, group based and structural approach to societal relevance.



At present, the committee believes that from an international comparative perspective, the societal relevance is very good, and at some points excellent.

#### *Conclusions*

After having assessed the research quality, relevance to society and viability, and comparing them to the developments and standards in the field of industrial engineering, the committee comes to the following quantitative assessments.

Research quality:	very good
Relevance to society:	very good
Viability:	very good

### **School of Innovation Sciences**

#### *Research quality*

The committee ascertained that the School's researchers publish in recognized international journals as well as in books and proceedings, and that they are delivering a very good research performance. The committee established that the research conducted at the School IS is well received by peers and that individual researchers and their work are well recognised internationally. The School has obtained competitive national grants from NWO, which is indicative of the recognition of the researchers. The success rates with large EU excellence funding schemes, such as MSC and ERC, lag somewhat behind. But with a number of new professors joining the School, the committee expects that successful research lines will be developed and funded. The school IS also has potential and notably a strategic ambition to increase the number of PhD candidates, and the aforementioned PhD scheme seems an appropriate strategy to realize that target.

#### *Societal relevance*

The School has a strategy for societal relevance that focuses on collaboration with societal and industrial stakeholders and the general public, mainly in the collaboration on research projects, the implementation of research outcomes, and social debates on the societal impact of innovations. This is substantiated with professorial positions that are funded by societal partners, and the committee considers this a mutual commitment to invest in the School's agenda for relevance to society. The committee would like to repeat its earlier conclusion for School IS: there still is substantial potential for increasing societal relevance. The Department as a whole should continue with the research theme policy and pursue a more explicit, specific and structural approach to societal relevance, including the involvement of and interaction with stakeholders and the dissemination of its findings. From an internationally comparative perspective, the committee thus assesses the relevance of School IS as very good, with examples that are good and some that are excellent.

#### *Conclusions*

After having assessed the research quality, relevance to society and viability, and comparing them to the developments and standards in the field of innovation sciences, the committee comes to the following quantitative assessments.

Research quality:	very good
Relevance to society:	very good
Viability:	very good

## **Department of Industrial Engineering and Innovation Sciences**

### *PhD programmes*

The two Schools have a very good selection policy for PhD candidates, of whom quite a few come from outside the Department. In order to improve the supervision and to decrease the completion time for PhD candidates, the respective graduate programmes have developed a more stringent policy for developing and approving the PhD proposals. The committee welcomes this policy. Topics the committee has discussed further are the roles of PhD candidates in teaching; the community building between PhD candidates of the two graduate programmes, and the opportunities for PhD's to have international research visits. As the Schools' PhD graduates take up interesting and relevant positions in research or industry, the Department should consider to deploy these alumni more actively in the graduate programmes.

### *Research integrity policy and data management*

The Schools and the TU/e have appropriate policy and training aimed at stimulating research integrity, and the committee is impressed with the key roles of staff members from School IS. The Department is an example of best practices for data management, and the committee applauds the initiatives taken to stimulate open science, replication of research and good statistical practices. As much research of the Department involves research with human subjects, the committee advises to install an ethical review board. Areas of some ethical concern are the intervention studies in (semi) public spaces, and the effect of the tenure track requirements on the PhD supervision.

### *Diversity*

The Schools have developed policies and targets for diversity in terms of gender, age and ethnicity. Notwithstanding some suggestions in the age diversity and the build-up of the Schools, the committee agrees with these overall policies, and stimulates the Schools to continue with realizing its ambitions.



## **4. STRATEGY, LEADERSHIP AND VIABILITY DEPARTMENT OF INDUSTRIAL ENGINEERING AND INNOVATION SCIENCES**

As explained in the terms of reference, the committee was requested first of all to consider the viability of the Department's longer-term strategy, and second, to compare this to similar departments in the international domain. The latter is done consistently throughout this review report: the evaluation presented here reflects how the panel members assess the Department and its Schools compared with institutes they are familiar with. The former is done here with explicit reference to the following:

- the research targets and research themes of the Schools and Department;
- the combination of disciplinary and interdisciplinary research;
- the tenure track policy, the teaching load and the effects on research;
- staff policy in view of size and mobility of staff.

Regarding the first two topics (targets and themes), the historical development of the Department and Schools is still visible. The predecessors of the Schools IE and IS have been working together in the Department for over twenty years. The Department was founded in the mid-1990s as the result of redistributions of research groups at university level. Eight years later, the two Schools were established. Until recently, the two Schools led more or less independent lives, but during this assessment period, they moved closer to each other. This is reflected in the formulation of the research targets and the strategic policy for research themes.

### *Research targets*

The committee reviewed the six research targets for both Schools, which were presented in the self-assessment reports. In contrast to the assessment period 2003-2009, they are now identical. The targets focus on the disciplinary, strategic and societal domains, and express a desire to build on the Department's strengths. Although the committee thinks that building on strengths is a good thing in itself, it has some comments to make in this case.

First of all, the targets could be formulated with a higher level of ambition, to match better TU/e's aim to be among Europe's top five engineering universities. The research targets would also benefit from being better operationalized, as they currently appear rather broad. The committee thinks that "continued disciplinary excellence" (target 1) is not very specific, and it is hard to assess if and when this target has been achieved. The same goes for "expanding the four research themes" (target 2): the committee required extensive discussion to understand what this entails. As the committee understands it, this is a work in progress, to be spelled out in the coming year.

Target 6 (maintaining the strong relationship with stakeholders) is at the core of the Department's strength to deliver socially relevant research. The target is certainly valid and fits with the department's already strong position in this area, but it would benefit from adding a purpose. Strong relationships with stakeholders can mean many things, and can be maintained in numerous ways. For the committee, it remained unclear what the objective of this target is exactly.

### *Research themes*

Recognizing that the two Schools have a potential for growth and collaboration that can be used for the benefit of the Department and its staff, the initiative was taken in 2015 to encourage the bottom-up development of research themes. These themes cut across the Schools and the research groups. Since the self-assessment reports were not entirely clear about the research themes, the committee held extensive discussions with both Schools and the Dean on the themes, their development and performance (expected). The committee presents its findings in this chapter.

Based on a series of discussions amongst senior staff and junior researchers, four research themes have been defined that embrace the research of both Schools:

1. Logistics and its interfaces,
2. Sustainability,
3. Value of big data, and
4. Humans and technology.

The identified themes are now being developed further. At the time of writing this report, a growth scenario for each theme was being operationalized by a theme leader. The themes are now also supported by one project development officer each. The theme leader will develop roadmaps for the theme, and the project development officer adds substance by tying in with funding opportunities, and creating links between the home researchers and external partners. The committee supports this organizational set-up, which appears to be adequate for driving the development of the research themes.

At the university level, Smart mobility, Health and Energy have been presented as the three strategic areas positioned alongside the research centres for Data science and High tech systems. The Department actively seeks to connect itself to a number of these areas, aiming for a growth scenario building on its own research strengths on the one hand, and the University's strategic policy on the other. The committee agrees that these themes hold potential for cooperation across the Schools, as well as connecting to the strategic areas of the TU/e.

Another part of the research theme strategy is an internal PhD scheme, to which the Department's researchers can apply. This is intended to kick-start cooperation between the research groups and Schools when PhD projects are awarded, and to prepare the development of joint proposals for external funding. The committee learned that one of the conditions for being awarded a joint PhD position is that it must be used to multiply the number of projects on this research topic. Specifically for tenure trackers, this is an important strategy to expand their research portfolio, and the committee applauds it. Each of the four research themes has benefitted from this scheme, with PhD projects run by staff members of the two Schools and the seven research groups.

The committee had some difficulty to grasp the essentials of the research theme policy from the self-assessment report. After discussions with many staff members, and in particular after an additional presentation by the Dean, the committee gained substantial understanding of and confidence in this strategy. The research theme policy has already been successful in creating a joint identity for the Department and in boosting new research projects across Schools and groups. The way ambitions are translated into concrete actions is likely to strengthen the focus and quality of the Department's research portfolio. The research themes also provide critical mass and visibility at the TU/e level, making the Department more relevant, e.g., in the context of developing the TU/e's strategic areas.

#### *Disciplinary and interdisciplinary research*

In addition to the research themes under development, the committee learned that the Schools each have a separate and historically developed strategy with regard to disciplinary and interdisciplinary research. On the one hand, both Schools aim to contribute to and benefit from state-of-the-art research in their specific sets of discipline (related to target 1), and in some cases have gained an excellent reputation in a very specific niche. On the other hand, the Schools seek to employ the knowledge and tools such focused research yields on projects and research questions in specified applied contexts. Disciplinary and interdisciplinary research are thus combined in a practical manner.



During the site visit, the committee had extensive discussions on how the interdisciplinary research is being directed. It appears that to a significant extent, researchers are looking to the available funds for projects to which they can demonstrably apply the tools, methods and

knowledge they have developed in their disciplinary research. As "Extending and diversifying funding activities" (target 5) is a target for both Schools, this seems valid, but efforts should be more focused so they do not appear to be a "strategy of doing more of everything". The committee recommends having a more explicit and content-driven agenda for interdisciplinary projects. With the research themes being developed, the committee expects that the successful yet somewhat contingent strategy for interdisciplinary research will be replaced by one that relates the interdisciplinary research more explicitly to the Department's strategic agenda. This will tend to make the interdisciplinary research strategy even stronger, thereby increasing the societal relevance of the Schools. Especially now that competition for research funding is becoming increasingly tough, this is a necessary next step.

#### *Tenure-track policy*

The committee also reviewed the tenure-track policy as a means to have young and talented academics develop future research lines. The outlines for the tenure-track policy have been developed at the university level, and the specific targets for granting tenure have been operationalized at the department level. During the site visit, the committee received valuable information regarding tenure-track policies and success rates.

From the documents and the interviews with excellent and motivated tenure-track academics (TTs), the committee learned that one of the criteria for being promoted to tenure is the successful (co-)supervision of two PhD candidates and the acquisition of two PhD positions (or equivalent) in funding. The Department sets the latter at a grant capture of €50,000 per annum. In addition to these conditions, the TT academics should produce an average of two (ISI) publications per year, build up a demonstrable scientific reputation and make a substantial contribution to education. The time frame for attaining these targets, and hence for being promoted from assistant professor to associate professor, is eight years, although legal requirements imply that TT staff receive a permanent contract after four years.

From what the committee learned during the site visit, it appears that the system is experiencing some serious strains. The target for the successful supervision of PhD candidates for example depends significantly on factors outside the control of the TT academics; there are numerous reasons for delay and drop-out of PhD candidates, and the TTs feel this to be a heavy burden. In addition to the strain this puts on individual TTs, the committee had some concerns about the possible negative, structural effects this dependency of TTs on the success of PhD candidates may have, such as the TT being involved too much in the work of the PhD, and the PhD candidate having too little freedom in the problem formulation and the intellectual content. These concerns are recognized by the Schools and the TTs and mainly addressed through the PhD selection and supervision policy. Overall, the committee assesses these risks to be of rather theoretical nature, but suggests continued focus on the topic.

#### *Teaching load*

The teaching load for staff in the two Schools affects research quality in direct and indirect ways, both of which are discussed in the self-assessment report. The direct effect is due to student numbers increasing tremendously with the creation of the Bachelor college in 2012. With the development of new courses and programmes, as well as with the increased teaching load, staff (including TTs) have had to cut in their research time, or work at the expense of their private life. As the self-assessment reports illustrate, both Schools experienced a significant increase in the number of EC (European Credits) per FTE, greatly exceeding the TU/e average. This increase in teaching load has had a negative impact specifically on the quantity of research output of both Schools.

Although the Department has been taking steps to reduce the teaching load, the committee learned from the interviews that the current student-staff ratio has reached the limits of what is bearable for the staff. One option being considered is to set a maximum limit on the number of students for specific degree programmes, thereby making the teaching load more manageable.

Furthermore, given the current strategic allocation model (SAM), the increase in student numbers goes hand in hand with an increase in direct funding. The Department has chosen to use the increased income to appoint teaching assistants (alleviating the teaching load) and PhD candidates (supporting the research themes). Thus, the Department and the Schools have made strategic choices in distributing funding and supporting research strategies. As more teaching staff without research time are appointed, the committee recommends that the Department safeguard the firm relation between teaching and research. Given the focus of the Department on this issue, the committee is confident that the situation will improve.

As expressed in the SWOT analysis of the Schools, the envisaged revision of the present SAM is likely to result in a significant and undesired decrease in direct funding. The committee shares the concerns of the Department, and hopes that its efforts in teaching continue to result in adequate levels of direct funding, especially since those revenues are used to support the Department's research policy.

#### *Size of research groups and staff mobility*

In the self-assessment reports the Schools, in particular School IS, reflect on staff mobility: leading researchers have taken up positions elsewhere or have retired. Although the fact that these researchers from the Department move to excellent positions elsewhere demonstrates the Department's high level of quality, the committee has some concerns regarding the follow-up of those who have left. The tenure-track scheme, the promotion of staff members, and the appointment of new professors from outside the TU/e are viable strategies to fill the gaps that remain, but they need time to bear fruit in terms of acquisition and the development of new, high-quality, societally relevant projects. Hence, the present actions might take a few years to effectuate.

One of the research groups, namely that in Philosophy and Ethics, differs from the others in having a smaller proportion of higher positions. There is only one full professor and two associate professors. According to the committee, it is of great importance to increase the number of associate professors in the next few years. Since the group has several highly competent researchers among its assistant professors, this can to a large extent be achieved through promotion. It is also urgent that the number of full professors be increased. To the committee's satisfaction, the Department was fully aware of this and proposed that a second full professorship be created in the domain of the ethics of technology.

## 4.1. VIABILITY

In reviewing the strategy, targets and leadership described in the previous section, the committee focused on the aspect of viability: how well do the strategic choices of the management of the Schools and Department respond to the external developments, and what influence will this have on the quality and sustainability of the Department and its Schools?

Overall, the committee believes that the Schools have a clear view of the challenges they face, and respond to them in a responsible and adequate manner. In particular, the Department's policy involving the research themes, in which bottom-up ideas are supported financially and strategically, is a case in point. Whereas in the past the Schools and research groups have been operating somewhat isolated from one another, the research theme strategy is a convincing way to create synergy between the groups, and to stimulate the development of new interdisciplinary research projects. The Department's policy to have projects from direct funding to generate



additional funding in second or third stream funding is also a sound way to make the research themes self-sustaining.

That policy will, in effect, stimulate the Schools' societal relevance, which thus far has resulted more from the work of isolated research groups than from the Schools and Department. In that sense, the committee is of the opinion that when successful, the research theme policy will further stimulate the viability, quality and societal relevance of the Schools.

In addition, the Department's view that both a cap on student numbers and investment in teaching assistants are needed to ensure the long-term viability of the Schools meets with the committee's approval. The pressure on the teaching staff, in particular since the establishment of the bachelor college, has had a negative impact on the research output. Although the research theme policy and financial investments have alleviated some of the negative impact, the committee is of the opinion that it must not get any worse, and more efforts should be made to secure the Schools' capacity for research.

There are a number of recommendations that follow from the committee's conclusions and observations. First of all, the six research targets could be formulated with a higher level of specificity and ambition, to match TU/e's ambition to be among Europe's top five engineering universities. The committee recommends developing the content of each research theme further – potentially through putting more emphasis on developing joint applications across research groups. The committee also suggests to broaden the scope of the "Logistics and its interfaces" theme by explicitly including more research groups into this theme. The committee raised the issue of increasing organisational complexity through establishing research themes across the formally established research groups. However, the committee is confident that the Department's initiatives to develop the research themes and resulting positive effects for research quality and viability merits the extra organisational and management effort.

A second recommendation, which is partly addressed to the leadership of the Department and partly to the Executive Board of the University, is to secure a sufficient level of direct funding by keeping the efforts in education and the revenues from the Strategic Allocation Model in balance. Furthermore, they should ensure that the staffing of all research groups is sufficient, especially in the area of Philosophy and Ethics.

## 4.2. CONCLUSION

After reviewing the strategy of the Department and the Schools, and assessing their related viability, the committee assesses the viability:

School for Industrial Engineering:	very good
School for Innovation Sciences:	very good



# 5. RESEARCH REVIEW SCHOOL OF INDUSTRIAL ENGINEERING OF EINDHOVEN UNIVERSITY OF TECHNOLOGY

## 5.1. RESEARCH QUALITY

### *Introduction*

The focus of the School of Industrial Engineering (IE) is to perform excellent research and provide outstanding education “in order to make business processes work in a high technology-driven environment”. This mission is translated in the work of four groups, each paying attention to a particular area in the business processes and operational engineering domain. The research group Innovation, Technology Entrepreneurship and Marketing (ITEM) focuses on understanding and improving new business and product development, and covers strategic, tactical and operational activities of new business and product development. The School regards this as its innovation management part. The human performance engineering aspects in operational, business and product development processes are addressed by the Human Performance Management group (HPM). The Operations, Planning, Accounting and Control (OPAC) group deals with the smart control of operational processes. The design, optimization and computer-aided support of operational and new business and product development processes within and between organizations are studied in the Information Systems group (IS).

### Assessment according to selected output indicators

In line with the instructions in SEP, the School IE has selected the output indicators that it considers important and relevant for the review of the research quality of its research groups. The committee has conducted its assessment in line with these indicators, which are:

1. Research products for peers (ISI publications and dissertations),
2. Use of research products by peers (citations, H-indexes and use of datasets, software tools, questionnaires and so forth),
3. Marks of recognition by peers (science awards and prizes, grants awarded by national and international science foundations, membership of scientific committees and editorial boards, number of PhDs who found employment in academia and technology research institutes, academic network, delivering keynote lectures).

The School IE aims to increase its research output in terms of ISI publications and ones in high-impact target journals. In the self-assessment report the School presented a list of target journals for publications, which was created following a number of typically used journal rankings and was composed primarily of top field journals. While the publication intensity of the School matches international standards, the committee believes the claimed increase is at most moderate. Nonetheless, the committee assesses the research quality of the School IE to be very good. Most of the key publications that were assessed by the committee are truly outstanding and influential, e.g., in terms of citations, H-indexes and awards. Those papers are rigorous in theory, thorough in analysis, and productive in application.

Overall, the committee concludes that the School's full-time researchers produce well-cited and internationally recognized research. The good reputation of the School is evidenced in H-indices (based on Web of Science) of full professors between 13 and 37 (two cases above 30), associate professors between 5 and 16, and assistant professors between 0 and 10. In this context, it is also notable that research methods (analytic techniques, questionnaires, etc.) developed at the department are used by peers. The listed examples show a very good ability to set standards in the respective research domain and add to the overall research portfolio, which is highly recognized by peers. The School also earned quite a number of scientific prizes for individual or team achievements, and delivered keynotes at international scientific conferences.



With respect to research funding, the School is very strong in acquiring funds in collaboration with industry and in relation to societal challenges, and as noticed, this is a focal point in the acquisition policy. National funds under the individual excellence umbrella have also been acquired, with increasing success over time. To further support the School's ambition for excellence in research, to secure a substantial basis for individual excellence development, and to further position the school in the group of internationally highly recognized research entities, the committee recommends putting more effort into acquiring European funding from the excellence pillar, such as ERC grants.

Members of the School are well recognized in their field, as evidenced by the scientific committees and editorial boards they participate on. The PhD alumni find good jobs in academia, research institutes and industry, although given the research profile of the School the committee would have expected a higher percentage of PhD graduates to find employment in industry.

The number of PhD candidates per FTE varied over the assessment period, and the committee believes the intake and quality of the PhD students are good. The PDEng scheme, in which design-oriented researchers follow a 2-year programme, is also performing well, with an average intake of 24 for the reviewed period. As the Schools have the potential and a clear strategic ambition to increase the number of PhD candidates to above 1.0 per staff, the aforementioned PhD scheme seems an appropriate strategy to realize that target.

#### *Research groups*

Along with these assessments at the level of the Schools, the committee also would like to highlight the achievements of the individual research groups.

#### *ITEM*

The ITEM group comprises 3 full-time and 2 part-time full professors, 2 associate (one of whom is on tenure track) and an impressive group of 17 assistant professors (13 of whom are on tenure track). This seems to be a very good mix of different career levels within the group, offering very good potential for continued growth in research.

The research group focuses on new business and product development processes in all different organizations with a specific emphasis on high-tech products. It applies multiple theoretical lenses and a wide range of methods to study innovation phenomena, and combines a management and engineering perspective in looking at these development processes. Through its staff and network, ITEM is thus able not just to conduct good disciplinary work, but also to connect to the themes and strategic areas of the Department and University.

With respect to research output, the group shows very good results, including some very influential publications in top domain journals like the Journal of Management Studies or Journal of Product Innovation Management.

This research group is well recognized internationally. Furthermore, the groups act as a talent incubator for many European universities, since former members of the group have transferred to renowned European research institutes, and have been able to attract good visiting scholars.

Overall, the committee is impressed by the ITEM research group's excellent research performance, both with respect to disciplinary research and impact on industry. The group is well equipped to continue its very positive development and is already now among the top research groups within their focused domain.

#### *HPM*

The HPM research group is the smallest group within the School IE with two full professors, two associate professors and six assistant professors, two of whom are in a tenure track position.

The research conducted in the group focuses on individual, team, and organizational factors related to performance enhancement and employee well-being. In particular, much of the research follows a very visible research programme with a high impact, based on the fundamental model of matching stressors and resources at work. This approach permits to provide insights systematically building on each other within a clearly defined research domain.

The two most highly cited professors of the Department are members of the HPM group, and the work of these professors acts as an umbrella for the work of the other staff members. Some of the younger researchers have complementary research interests also, e.g. on team processes, decision-making and goal-setting, which provides for a useful broadening of the research portfolio and new opportunities for collaboration within the department. Overall, the research productivity and quality are excellent, and the HPM group can clearly be considered as one of the most influential groups in the international job stress research community. The theoretical job stress models are indicative of this quality and the recognition in the discipline. At the same time, the committee observes that although this group has a very narrow disciplinary focus, it is accompanied by a diverse array of applied studies.

This diversity in applied studies is illustrated by the fact that during the evaluation period, several members of the group increasingly worked on intervention projects in practice. This strongly contributes to the growing relevance to society of the IE school, but at the same time the committee learned from the interviews that the strategy in starting these projects is mostly opportunity-driven, and to a lesser extent systematically built and explicitly coordinated.

#### *OPAC*

The OPAC group consists of seven professors, three associate professors and 16 assistant professors, and thus is one of the largest groups in the Department. Quite a few assistant professors are in the tenure track to become associate professor, which is an important development, given the relatively low number of associate professors. The institutes these candidates came from are of high standing, and with these tenure-track candidates the continuity in research quality seems assured. Despite the fact that some members left in recent years, the committee feels the group is well secured for the future.

The committee acknowledges that this research group has made significant contributions to the field of logistics, both from a methodological and an applied perspective. The research quality of this group is excellent. For example, the first key publication of Donselaar et al. mentioned reports on a field study that combines behaviour operations management with retail operation to make a fundamental contribution in both fields. The paper sets a model of academic brilliance for a behaviour and empirical study that uses big data collected from an industrial setting, and is thus exemplary of the group's practice-based research. Other publications demonstrated a similar approach, for example by being co-authored by industry executives.

These co-authorships with industry set a model for academia-industry collaboration beyond the joint funding of research projects currently done in universities, as the group's heavy involvement in the Top sector logistics also illustrates. Furthermore, the implementation of the outcome of such research projects in industry applications has strengthened the demonstration of the societal impact.

#### *IS*

The Information Systems (IS) group currently has two full-time and one part-time full professors, three associate professors, and nine assistant professors (eight tenure-track), which appears to be a healthy distribution of different career levels offering good career paths and perspectives, which will intensify existing fields of research and also sufficiently address new emerging fields.



The research group focuses on business process management and business process intelligence. This structure clearly reflects the main drivers of information systems research, namely processes and methods. Given the breadth of the field of information systems, IS is

currently targeting selected areas. Although the IS group is already quite large, additional growth would be required to be able to cover the field of information systems completely in sufficient depth.

Very good research results have been achieved, ranging from business model frameworks and platforms (such as BASE/X and Gamebus) to outstanding publications in highly ranked conferences and journals, including best paper awards. In some selected research fields such as computational intelligence, fuzzy systems, and decision-making, the IS group is internationally recognized as one of the world leaders with respect to publications, visibility in the academic community, and real-world applications.

This top quality of the IS group is further confirmed by substantial research funding and significant presence at international conferences, including the organization of the IPMU 2016 conference in Eindhoven.

The committee is impressed by the research excellence of the IS group as demonstrated by high-quality publications, outstanding scientific visibility, and very good industrial impact, and would like to encourage the group to continue to implement, extend, and grow the existing successful research strategy.

## 5.2. RELEVANCE TO SOCIETY

As with the research quality, the School IE defined a number of criteria in line with the SEP with which it prefers to be assessed on its relevance to society. These criteria focus on research products for societal groups (written output, instruments and software, and outreach activities), the use of those products (collaborative projects, use of textbooks and instruments), and marks of recognition by societal groups (committee memberships, funding and prizes). The committee assessed the relevance to society of the School IE with these criteria.

In general, the School's research and activities are positioned close to industry, taking advantage of being located in a EU high-tech hotspot. It is therefore not surprising that the School takes an almost classical engineering school approach ("practice-based research"), combining very good international competitive research with real industry problems. With this good and pragmatic strategy, the School is securing adequate means for converting research results into solutions, as evidenced by the amount of grant money that has come from industry and third parties. Societal relevance and collaboration with industry are thus the bread and butter of this School.

The committee learned that the School also cooperates intensely with industry through internships and theses projects in its degree programmes. Having over 90% of master theses performed in collaboration with industry and other societal entities is remarkable. Also the fact that more than half of the PhD graduates from the IE school have continued their career in industry reflects the relevance of the school's research activities to industry and society. Thus, the increase in student numbers also creates opportunities for strengthening the collaboration with societal and industrial partners at the student, PhD and postdoc level. This has a positive and demonstrable effect on stimulating societal relevance and contract research.

The School IE operates a broad set of different means to ensure that its research results have a concrete impact in industry, and the self-assessment report provided sufficient evidence for the very good to excellent nature of these collaborations. Also, participating in industry fora and hosting the European Supply Chain Forum with top industry involvement highlight the school's very good activity level for becoming and staying highly relevant to society. The information

systems (IS) group has yielded impressive real world impacts in many joint projects with industrial application partners (BASE/X, GET, Gamebus, Tracebook). Still, the group could increase its impact with a higher number of PhD graduates continuing their career in industry. The OPAC group is excelling with its involvement in the top sector logistics. Collaborations with

Philips, ASML and TKI Dinalog are also noteworthy. The HPM group is widely recognized by the field in the uptake of the instruments it has created for detecting job-related stress, but should take the next step by systematically setting up intervention studies to increase immediate impact in organizations and provide ecologically valid knowledge for policy-makers. ITEM is heavily engaged with many activities and has good funding from industry. The committee noted in particular ITEM's central contribution to the growth of the InnoEnergy KIC, contributions to the business side on TUE's flagship project on public lighting, and multiple teaching and learning related initiatives for promoting start-up entrepreneurship. Notably, ITEM is also engaged in shaping the public debate on creating favourable conditions for innovation in the EU.

To date, societal relevance is mainly created at the level of the specific, excellent projects and by individual and prominent researchers. Given the research power and close industry ties of TU/e as a whole and the integral and socio-technical nature of the strategic challenges TU/e has defined for itself, there is still a substantial, unrealized potential for the School IE to be relevant to society and industry. In the above discussion on strategy, the committee already expressed its confidence in the research theme strategy to realize more focus in the targets for interdisciplinary research and the collaboration with societal and industrial partners. The committee thus concludes that in order to further develop, the Department as a whole should continue with the research theme policy and pursue a more explicit, specific and structural approach to societal relevance. At present, the committee believes that from an international comparative perspective, the societal relevance is very good, and at some points excellent.

### 5.3. CONCLUSIONS AND OVERVIEW OF QUANTITATIVE ASSESSMENT

After having assessed the research quality, relevance to society and viability, and comparing that to the developments and standards in the field of industrial engineering, the committee comes to the following quantitative assessments.

Research quality:	very good
Relevance to society:	very good
Viability:	very good



## 6. RESEARCH REVIEW SCHOOL OF INNOVATION SCIENCES OF EINDHOVEN UNIVERSITY OF TECHNOLOGY

### 6.1. RESEARCH QUALITY

#### *Introduction*

The mission of the School of Innovation Sciences (IS) is to carry out excellent scientific research on the interactions between humans, society and technology, investigating the ways in which humans and societies bring about technological change, and understanding how technological innovations change society and human behaviour. The School's research addresses the grand challenges that contemporary societies face, such as those related to energy, health and mobility. These challenges are relevant on different levels of aggregation, from interactions with technology on a small and individual scale, to large-scale and long-term societal transitions. In order to fulfil the School's mission, the research programs are rooted in various disciplinary perspectives from the humanities and social sciences, and apply different scientific approaches, ranging from description and analysis, intervention (policy, management, design, experiment) to critical reflection and normative evaluation. Research at the School IS is embedded in three research groups: Human-Technology Interaction (HTI), Philosophy and Ethics (P&E) and Technology, Innovation and Society (TIS).

#### *Assessment according to selected output indicators*

In line with the instructions in the SEP, the School IS has selected the output indicators that they consider important and relevant for the assessment of the research quality of its research groups. These output indicators are:

1. Research products for peers (articles and special issues in peer-reviewed journals, edited books, monographs and book chapters with leading academic publishers and PhD dissertations),
2. Use of research products by peers (citations and substantive discussion in others' research products such as reviews or book symposia),
3. Marks of recognition by peers (science awards and prizes, grants awarded by national or international science foundations, membership of scientific committees or editorial boards and delivering keynote lectures). The committee has conducted its assessment with these indicators.

The committee ascertained that the School's researchers publish in recognized international journals as well as in books and proceedings, and that they are delivering a very good research performance. The research output in journal publications of around 3-4 papers per FTE is very good and matches international standards.

According to the committee, the School's research is well received by peers, as evidenced by a list of very good journal publications which have been cited more than 50 times. Also, examples of the use of their research at symposia and in other collaborative research endeavours are notable. Several members of staff are active on scientific committees and the editorial boards of a number of peer-reviewed international journals. Some of the School's researchers also delivered keynote lectures at international conferences, for instance at Beijing Forum in 2015 and Robotica 2012, and received awards for their publications, which is indicative of their recognition by peers.

The School has obtained four VIDI grants from NWO, individual grants for mid-career academics, which is indicative of the recognition of the researchers. Furthermore, the committee is impressed that the School's programmes were awarded several NWO MVI, WOTRO, KIC Climate and TKI top sector grants, as well as funds from a number of European schemes, such as Horizon 2020, CORDIS and BATWOMAN. However, in the eyes of the committee, the success rates with large EU excellence funding schemes, such as MSC and ERC, lag somewhat behind. The committee



established that the research conducted at the School IS is well received by peers and that individual researchers and their work are well recognised internationally.

The school has a good intake of PhD students (with a minor dip in numbers in 2012 and 2013). Over the years the school has had 0.6 to 0.8 PhD students per scientific staff member (almost equal to the School IE). Hence, both schools have potential and notably a strategic ambition to increase the number of PhD candidates to above 1.0 per staff, and the aforementioned PhD scheme seems an appropriate strategy to realize that target.

## **Research groups**

### *Philosophy & Ethics*

The Philosophy and Ethics group consists of one full professor, two part-time associate professors and eight assistant professors, of whom six are in a tenure track to associate professor.

The group's research focuses on the interface between fundamental philosophical issues and real-world problems that arise from the design and use of innovative technologies. Their work on the dual nature of technological artefacts laid the foundations for a new discussion on the metaphysical nature of technology, a discussion that puts the work of engineers at the centre.

The committee noted that this focus was followed by a series of projects on technological function that has opened up several new perspectives in the philosophy of technology. The work has provided a new basis for philosophical studies of design, and according to the panel it has contributed much to the clarification of the relationship between technology and science. Both the work on the dual nature and that on technological function have had a thorough and worldwide influence on philosophical studies of technology. The committee concluded that, despite its moderate size, the group has not only established a remarkable track record of influential contributions to the philosophy of technology, but also fulfilled a leading role in the transformation of research in this field.

Looking at the most recent work in the group, including new studies on technological function and investigations of how cultural evolution relates to technology, the committee is convinced that the group has maintained its leading role in this discipline in recent years. In its view, the P&E group performs research of excellent quality and is a world leader in its field, the philosophy of technology.

### *Technology, Innovation and Society*

The research group Technology, Innovation and Society has seven full professors, four of whom have part-time contracts of 0.1, 0.2 and 0.5 fte. There are four associate professors and six assistant professors, of whom three are in a tenure track. As the committee learned during the site visit, the group has had financial difficulties in the past, which the current programme leader has addressed very effectively. The committee congratulates the group on this.

The group is developing a multi-faceted and multi-disciplinary research agenda, while focussing quite strongly on themes such as sustainable innovations, renewable energy and socio-economic processes aiming at 'greening the economy'. The committee thinks that this clear focus is a strong point, given the relatively small size of the group. It also notes that the convergence of various disciplines and approaches towards common empirical themes is fruitful and productive. In this sense, and because the group is clearly dealing with applied (not fundamental) research, the panel considers such eclecticism a good thing: multiple approaches and disciplines are needed to investigate different aspects and dimensions of the research objects studied. This concerns mainly problems about the generation and diffusion of clean technologies and green innovations.



At the same time, the committee observed that the group is too eclectic in terms of reference to theories and disciplines. On the one hand, this is a strength as it delves from rich theoretical

resources, but on the other, the cost of thematic focus and empirical eclecticism also makes publishing in the top generalist journals difficult. In the committee's opinion, this is reflected in the publication record of the group in which specialised journals are dominant. The research group should consider targeting some top generalists journals to publish their best research findings.

The self-evaluation report notes that staff mobility has been a challenge, but that in recent years, new professors have been appointed. The committee applauds the challenging and stimulating research agenda created in this group, in which rigour and relevance are mutually reinforcing, and expects the group to flourish as the newly appointed professors build up their research programmes.

#### *Human-Technology Interaction*

The committee observed that with two full-time and four part-time full professors, two associated professors, and seven assistant professors (six in a tenure track), the HTI group has a sufficient size to encourage cooperation by multiple members around particular lasting themes and within specific projects. Thus, the group maintains internal coherence while at the same time showing an ability to move on novel topics.

In the opinion of the committee, the HTI group makes distinctive scientific and practical contributions concerned with interactions between people and technology in a wide range of contexts. In their research, group members demonstrate well-refined disciplinary capabilities, mainly across the field of psychology. The committee observed that the group members are clearly producing research of excellent quality, as exemplified by the publications submitted with the self-assessment report, which have been published in leading journals in their respective fields. This confirms sound knowledge of basic processes (e.g., with regard to visual and haptic perception, physiological stress responses, emotional expression, interpersonal relations), the development of useful psychometric measurement instruments (e.g., for the sense of presence in mediated environments), masterful applications of innovative methods (often experimental), and their role as proponents of cumulative science.

The committee noted that, at the same time, group members orient toward diverse practical issues, looking at neglected or misunderstood needs and limitations of users who do or could engage with a technology. One notable research program of long standing, that of the Intelligent Lighting Institute, addresses light, lighting and behaviour, with studies often pursued in cooperation with the Philips company in Eindhoven. Another example involves work around mediated environments, which includes a seminal demonstration in the *Journal of Environmental Psychology* of the use of virtual reality for representing stress-reducing environments.

Colleagues in the HTI group are highly regarded internationally for their contributions in these and other areas. The scale of the group's research results compares well with that of productive units elsewhere, such as the Institute for Housing and Urban Research at Uppsala University and the Environmental Psychology Group within the Department of Architecture and Built Environment at the Lund Institute of Technology. Considered simply in terms of the number of publications per research fte, there are between 3 and 4 items in the Web of Science per year as a rough estimate for the more senior members, excluding high outliers.

## 6.2. RELEVANCE TO SOCIETY

As with the research quality, the School IS defined a number of indicators in line with the SEP with which it prefers to be assessed on relevance to society. They focus on research products for societal groups (written output, and outreach activities, educational products, and public



dissemination), the use of these products (impact on stakeholders, collaborative projects, use of textbooks), and marks of recognition by societal groups (committee memberships, funding,

prizes and appointments by societal groups). The committee assessed the relevance to society with these indicators.

The School has a strategy for societal relevance that focuses on collaboration with societal and industrial stakeholders and the general public, mainly in the collaboration on research projects, the implementation of research outcomes, and social debates on the societal impact of innovations.

The record of the School and its particular groups shows an impressive degree of involvement with actors outside of academia, including industry and the public sector. This is reflected in project funding, authorship, the applied character of much of the work, and the national and international scope of these collaborations. Some of these cooperative relationships are of long standing, notably the work with light, lighting and behaviour supported by the Philips company and its research operations. Some 13 PhD students are co-supervised by members of HTI within public/private partnerships between Philips and TU/e, and thus a substantial number of people in the research environment act in an immediate way to effect knowledge transfer to industry. It is not only a matter of serving industry, however.

The P&E research group in Eindhoven had a major impact in driving development in the field of the philosophy of technology, as testified by the seminal handbook *Philosophy of Technology and Engineering Sciences*, published in 2009. It should also be mentioned that their work on technological function has considerable influence in other areas, not least in the philosophy of biology. Furthermore, the P&E group is central to the university's training, advice and policy for scientific integrity, which should be taken as another sign of societal relevance. The School (specifically TIS) also contributed to a study for the European Commission on patents and standards, which included politicians as well as many societal stakeholders.

One project singled out in the self-assessment report deserves mention here, and that is the award-winning De-Escalate project, done in cooperation with Philips Lighting, the Municipality of Eindhoven, the local police, and a local association of bar owners, who are looking to the project for help in reducing aggression among visitors to bars in a popular nightlife area in the city. The project considers how relatively simple and inexpensive environmental interventions might help in preventing problematic behaviour from escalating in a variety of crowded outdoor situations and in small-scale indoor settings. This project is an example of excellent societal relevance.

Finally, the committee is very positive about the professorial positions that are funded by societal partners, and considers this a mutual commitment to invest in the School's agenda for relevance to society.

To conclude on the relevance to society for School IS, the committee would like to repeat its earlier conclusion for School IE: To date, societal relevance has been mainly created at the level of the specific, excellent projects and by individual and leading researchers. Given the research power and close industry ties of TU/e as a whole and the integral and socio-technical nature of the strategic challenges TU/e has defined for itself, there is still a substantial unrealized potential to be relevant to society also for School IS. In the above discussion on strategy, the committee already expressed its confidence in the research theme strategy to realize more focus in the targets for interdisciplinary research and the collaboration with societal and industrial partners. It thus concludes that in order to excel further, the Department as a whole should continue with the research theme policy and pursue a more explicit, specific and structural approach to societal relevance, including the involvement of and interaction with stakeholders and the dissemination of its findings. From an internationally comparative perspective, the committee thus assesses



the relevance of School IS as very good, with examples that are good and some that are excellent.

### 6.3. CONCLUSIONS AND OVERVIEW OF QUANTITATIVE ASSESSMENT

After having assessed the research quality, relevance to society and viability, and comparing them to the developments and standards in the field of innovation sciences, the committee comes to the following quantitative assessments.

Research quality:	very good
Relevance to society:	very good
Viability:	very good

## 7. PHD PROGRAMMES

Along with the quantitative assessment of quality, relevance to society and viability, the committee also presents a qualitative assessment of the PhD programmes, integrity and data management policy, and diversity. These topics will be the subject of this and the following two chapters.

During the site visit, the committee met with the directors of the two graduate programmes and a selection of PhD candidates, and interacted with them during a poster presentation session. It discussed a number of issues with them, such as the time to completion, the supervision and mentoring, and the training.

The Schools apply rigorous selection criteria for admission and attract quite a number of PhD candidates from outside their own degree programmes. Once they have been accepted, the candidates develop a personal education plan, comprising a number of core courses dealing with general academic skills, as well as specific courses for their PhD projects. They also draw up a development plan in the first three months. After nine months their progress is reviewed and a go/no go decision is made for the rest of the PhD-project.

With this policy, which has become more stringent in recent years, the graduate programmes hope to decrease the time to completion and to select suitable candidates in the first year. Given the reported numbers for completion within five years (58% for School IE, 28% for School IS), the Schools should make greater efforts to improve this situation. Of course, the committee takes into consideration that these rates are 'polluted' by factors the Schools cannot control, such as maternity leave, PhD candidates who combine the research with a job, and so forth. Still, the committee considers this more stringent PhD policy both necessary and appropriate.

Another element that deserves attention is the use of PhD candidates in teaching. As discussed above, one of the challenges for the Schools has been the increased teaching load. PhD candidates have a teaching obligation of 15% at most. But as some wish to develop their teaching skills and work on their university teaching qualification (BKO), the Department could consider a scheme in which PhD candidates have a larger teaching appointment.

The committee's general impression is that the PhD community at the School IS is energetic and ambitious, but contacts and collaboration between research groups in the School and with the School IE could be enhanced. For example, it struck the committee that quite a few PhD candidates in the two Schools are working on comparable topics, but without being aware of each other's existence. However valuable the present social events may be, the Schools could and should stimulate the building of one PhD community in the Department. The research themes strategy discussed under the headings of viability can be a means to do so, but other avenues should also be explored.

Furthermore, the committee learned that supervisors are very willing to encourage the candidates to go abroad. However, the PhD candidates do not get the impression that there is a clear policy in place, with appropriate financial support. The committee recommends translating the Schools' intent to strongly encourage external research stays during the PhD period into sufficient means to do so, and ensuring all candidates are invited to apply.

The alumni job placement is quite successful, with approximately 40% of graduates finding a career in research (institute/university). The committee observed that quite a few alumni have ended up in fascinating positions, but this network is not actively used in the PhD programmes. The committee recommends developing a strong alumni network, from which the Schools, research themes and PhD candidates can benefit.



The committee concludes that the Schools have a very good intake of PhD candidates who examine fascinating topics that can act as bridges between the Schools and groups. The outflow of PhD candidates to industry and research is good. Still, the committee has identified a number of areas that can be improved: the building of a PhD community at the Department level deserves much more attention, as does the alumni policy. The new supervision policy, with the go/no go moment in year 1, is welcomed and necessary to reduce the time to completion. Finally, opportunities for gaining advanced teaching experience and for going abroad should be a structural part of the PhD policy, supported by sufficient means and information provision.

## 8. RESEARCH INTEGRITY POLICY & DATA MANAGEMENT

The schools described their policies and practices for research integrity and data management in three areas: the adherence to university policies, the definition and maintenance of discipline-specific standards, and activities to support integrity outside the school.

The university has appropriate policies in place for safeguarding and stimulating scientific integrity. Based on the code of conduct of the Association of universities in the Netherlands, the TU/e has prepared its own code of conduct, and existing and new researchers sign it. The University has one confidentiality officer, with whom employees can discuss potential violations of integrity. Complaints can be addressed to the University's Complaint committee for scientific integrity. Along with the formal structures and procedures, the TU/e has an Advisory council for scientific integrity, which helps to develop policies that apply to the University in general as well as to the diverse disciplines. Until 2013, Prof. Anthonie Meijers, full professor of the Philosophy and Ethics group, acted as confidentiality officer, and since 2013 he has chaired the Advisory council. The P&E group also offers the Scientific Integrity course, which is compulsory for all TU/e PhD candidates. After reviewing the policies and procedures at the university level, the committee concludes that they are appropriate and sound, and the involvement of the P&E group is an important sign of relevance of the group for the University.

As the committee learned from the documentation and during the site visit, the Department has a very good focus on research integrity. There is a whistleblower policy, sufficient training (mostly at the PhD level), and the Department is creating awareness through "staff contracts". Additionally, it has implemented means for establishing and maintaining a culture of integrity, which presents the Department as an internationally good practice case. For data management (e.g., ensuring that access to PhD project data is available), the Department can even be identified as a best practice example.

At the level of the disciplines, the HPM and HTI groups are compliant with specific policies for research involving human subjects. The potential installation of an ethical review board to approve applications for new experiments or intervention studies is being discussed by the Department; for HTI the daily board of the group is performing this task pending the implementation of further policies, and has a dedicated system for this (ARCHIE). The committee notes that a dedicated ethical review board would comply with the policy defined by the Discipline group for the Social Sciences (DSW).

Both the HTI and the HPM groups comply with the guidelines for data storage of the American Psychological Association. The committee was impressed with the HTI initiatives for promoting open science, replication research and good statistical practices. This can be taken as a model for the integration of sound research practices, safe storage of private data, and the sharing of data.

The future challenges faced by both Schools concern studies (intervention) in companies, institutions or public spaces. The Schools are clearly aware of the potential risks for the participants involved and the necessity for safeguarding ethical boundaries. It is important that the Advisory Council is developing advice on this, but the appropriate follow-up in terms of policies is crucial.

The committee noted a potential challenge to integrity with respect to TU/e's tenure guidelines. As tenure-track staff must acquire funding for two PhD students, and supervise two PhD students to a successful conclusion, rules for maintaining sufficient distance between the tenure-track supervisor and individual PhD projects may be compromised: the PhD candidate might be assisted too much because the tenure-track academic needs this successful PhD in order to obtain



tenure. Although this seems a theoretical risk and safeguards are in place to prevent this, the committee believes it will continue to be a point of concern, which the tenure-track policy should address.

In conclusion, the committee is very satisfied with the policies and practices for ensuring integrity and good data management. In some areas, the Department is fulfilling a leading role, such as data sharing, replication, and training and advice. Still, the Schools would benefit from a dedicated Ethical Review Board, complying with national policies for integrity in the social sciences.

## 9. DIVERSITY

The targets and policies for a balanced composition of staffing for the Schools are subject to Departmental policy. For example, the Department has defined targets for the percentage of female staff members in 2020: 30% should be full professor, 30% associate professor and 35% assistant professor. Compared to the university targets for 2020 and the average of the national targets for 2015, the Department's targets are more ambitious for the full and associate professors.

The committee is very pleased to see that School IS has exceeded these targets for the full and assistant professors, but is also aware that realization of the targets requires continuous, sustained efforts. The School IE is still lagging behind the Departmental target: only 12.5% of female staff is full professor, and 22.2% associate professor. Only the assistant professors exceed the target: 43.1%. The committee recommends reassessing current efforts to attain the numbers. It is positive about the potential of the tenure-track systems, and the fact that two female staff members are on the selection committees. The committee hopes that this will contribute to a more balanced composition in terms of gender, especially in School IE.

The Schools differ in how age is distributed. The desired situation is to have a fair proportion of staff members who are at the beginning of their careers. School IE is well underway with this, and School IS is investing in this in the near future. Although the committee supports the rationale for this 'age policy', the Department should also keep a keen eye on sufficient appointments at the professorial level, as well as attracting staff members with proven academic reputations.

In terms of nationality, the committee is pleased with the wide diversity of the staff. In the self-assessment report, the Schools expressed the expectation that given their educational focus and load, at least one-third of the staff should be international. This is currently being met.

To conclude, the Schools have a clear and ambitious policy for diversity in place that addresses the topic along dimensions like age (seniority), gender and nationality. The committee agrees with the general outlines, and has presented some concerns and considerations.



## 10. CONCLUSIONS AND RECOMMENDATIONS

### 10.1. QUALITY OF INDUSTRIAL ENGINEERING AND INNOVATION SCIENCES

The committee has assessed the research quality and societal relevance for the Schools for Industrial Engineering and for Innovation Sciences separately, and assessed viability in an integrated manner. The PhD programmes, integrity policy and data management, and diversity are also discussed at the department level.

To start with the strategy and viability as the backdrop for the assessment of the Schools, the committee concludes that the recently developed research theme policy is very good and a necessary step to develop the research portfolio of the Department. The research theme strategy aims to make optimal use of most of the expertise within the two Schools, and this will bear fruit for the quality and relevance of the whole Department, including closer collaboration and interaction between the Schools and the different research groups within them. The committee believes that as a result, the research targets of the Schools can be made more specific and ambitious in the future. This, for example, applies to targets for disciplinary and interdisciplinary excellence.

The Department is responding well to external challenges, such as the creation and further development of the bachelor college at the TU/e, which has put a substantial additional teaching burden on the teaching staff. The revenues from such additional teaching are being used to hire more teaching staff and to employ more PhD candidates, which the committee supports. The committee shares the concerns of the Department that changes to the Strategic Allocation Model might negatively impact the Department's research strategy.

#### **School IE**

The committee has ascertained that the quality of research in the School IE is high. The School as such, as well as the individual research groups, are "very good" on average in both the disciplinary and interdisciplinary research projects, with a heavy concentration on collaboration with industry.

The output of the School in ISI journals is very good, and based on citations and the uptake of the work produced, the researchers are clearly recognized in their respective fields. Furthermore, the surveys and instruments they develop are frequently used by fellow researchers, indicative of the peer recognition of the School. The School has many interactions with industry in master and PhD projects, and the PDEng scheme, in which design-oriented researchers follow a 2-year programme, further stimulates the connection between research and industry. The research groups participate in many relevant projects, some of excellent quality: the School has listed many, and often impressive examples of the performance of research groups and individuals. The collaboration with industry is intense and very good, and the committee regards the research theme policy as a necessary strategy to further develop the way the School interacts with and is relevant for society.

Research quality:	very good
Relevance to society:	very good
Viability:	very good

#### **School IS**

The committee ascertained that the quality of research in the School IS is high, and the respective groups are very well recognized in their fields of research. The School's researchers publish in recognized international journals as well as in books and proceedings, which represent more relevant publication forms in some research fields, and are delivering a "very good" research





quality on average. The annual research output in journal publications of around 3-4 papers per researcher fte is very good and matches international standards. Researchers deliver many keynote lectures, have a good grant capture, and are actively involved on many editorial boards. In addition, the output in terms of PhD candidates is up to standard, and the School has everything in place to raise that number further.

The School has made important contributions to society, for example by developing widely used teaching materials in the field of ethics and technology, contributing to policy development on patents, or using research projects to study and resolve problems in Eindhoven's city nightlife. Existing challenges for the School are the recent mobility of staff in some groups, or the lack of senior staff in others. The committee is confident that the Department will be able to address these challenges adequately.

Research quality:	very good
Relevance to society:	very good
Viability:	very good

### **Recommendations**

The committee would like to make the following recommendations:

1. The Schools should formulate the research targets in such a way that it becomes clear what is to be attained, when and why. Expressing more ambition regarding the themes would also make them more targeted;
2. Continue with the planned implementation of the research themes. The committee believes that this strategy is a very good way to raise the research quality and societal relevance to an even higher level of accomplishment;
3. Exert more efforts to secure European grant schemes for individual researchers, such as ERC grants;
4. Specify better what disciplinary excellence entails, also in relation to interdisciplinary research. The latter now seems more or less contingent (based on the funding opportunities); both disciplinary and interdisciplinary research could benefit from a more explicit philosophy. The research theme policy can help with that;
5. With regard to the tenure-track policy, reconsider the criteria for tenure (such as the successful completion of two PhD trajectories) since the success of a PhD doesn't solely depend on the qualities of the tenure-track candidate. Furthermore, an overreliance of the tenure-track candidate on the success of the PhD candidate may result in undue support of the latter by the former;
6. Continue with safeguarding the balance between teaching, the increased revenues this has (and will) yielded, the effects on research quality. Preserve a close connection between research and teaching.

## **10.2. RECOMMENDATIONS FOR PHD PROGRAMMES, INTEGRITY AND DIVERSITY**

The committee assessed the Department's PhD programmes, integrity policy and data management, and diversity in qualitative terms.

The recent changes in the training and supervision of PhD candidates is welcomed by the committee. The individual training programme and the clear structure of the supervision trajectory are regarded as a strategy that is needed to improve the timely completion of PhD candidates. In a social sense, the Department should stimulate the building of a PhD community across the Schools.



The Department, Schools and individual groups are very up to date with training, policy and procedures for ensuring and promoting integrity and sound data management practices. The committee supports the idea of an Ethical Review Board for assessing research proposals involving human subjects.

Finally, the Department is very aware of the need for diversity in terms of age, gender and ethnicity. It is actively steering towards having a mixed community of researchers, and is ambitious in the goals it would like to attain.

### **Recommendations**

The committee would like to make the following recommendations:

1. The Department should make sustained efforts to build a stronger PhD community. In social and intellectual terms, the PhD candidates from the Schools and research groups appear to be working in a fashion that is too isolated. The PhD candidates can be a source of support and inspiration to each other, and given the long PhD completion times and focus on shared research themes, this is something the Department and graduate programmes should encourage.
2. The Department should make more effort to set up an alumni network. The committee thinks this can have many benefits for current PhD candidates, students and the research portfolio of the Department.
3. The Department has set ambitious targets for the number of female staff members. Although in some areas these numbers are being met, in others they are not. The committee recommends the Department continue working on this.
4. In view of the past staff mobility, ensure that the number of senior staff members is up to standard. The Schools' focus on hiring junior staff members as tenure-track candidates is appreciated, but the necessity of having sufficient senior staff members should not be underestimated.

# APPENDICES





## APPENDIX 1: EXPLANATION OF THE SEP CRITERIA AND CATEGORIES

There are three criteria that have to be assessed.

Research quality:

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

Relevance to society:

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

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

Viability:

- o 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;
- o 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 recognised 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

**Luc Soete** is honorary professor of economics and former Rector Magnificus of Maastricht University. He is a member of the Royal Netherlands Academy of Arts and Sciences. Professor Soete has been widely published in theoretical, empirical and policy analysis of innovation. In 1988, he founded the Maastricht Economic Research institute on Innovation and Technology (MERIT), which became integrated in 2005 into UNU-MERIT.

**Dominique Foray** is professor at the Ecole Polytechnique Fédérale de Lausanne (EPFL) and holds the Chair of Economics and Management of Innovation (CEMI). His expertise includes the economics of innovation and knowledge and the economic policy implications of the new knowledge-based economy. He has is member or chair of various councils, and has presented many opening speeches and key note address in academic and policy conferences on these topics. He has written numerous academic papers as well as two books and have edited several books and special issues in these fields.

**Gudela Grote** is Professor of Work and Organizational Psychology at the Department of Management, Technology, and Economics at the ETH Zürich, Switzerland. She received her PhD in Industrial/Organizational Psychology from the Georgia Institute of Technology, Atlanta, USA. She has published widely on topics in organizational behavior, human factors, human resource management, and safety management. Prof. Grote is associate editor of the journal Safety Science and past president of the European Association of Work and Organizational Psychology.

**Sven Ove Hansson** is professor in philosophy at the Department of Philosophy and History, Royal Institute of Technology (KTH), Stockholm. He is editor-in-chief of *Theoria* and of the two book series *Philosophy, Technology and Society* (Rowman & Littlefield International) and *Outstanding Contributions to Logic* (Springer). His research areas include philosophy of science and technology, epistemology, logic, fundamental and applied moral theory, value theory, and political philosophy. He is the author of well over 300 articles in international refereed journals. He is member of the Royal Swedish Academy of Engineering Sciences (IVA) and Past President of the Society for Philosophy and Technology.

**Terry Hartig**, Ph.D., M.P.H., has more than 30 years of experience studying how processes of psychological restoration are supported by features of work, residential, leisure and institutional contexts. He currently holds a professorship in environmental psychology with the Institute for Housing and Urban Research at Uppsala University. He serves on the board of directors of the International Association for Applied Psychology, the coordination committee of the European Network for Housing Research, and the editorial boards of the *Journal of Environmental Psychology* and other journals. He is a frequently cited contributor to the literature on urban green space, nature experience and health.

**Chung-Yee Lee** is currently Director of the Office of Institutional Research at Hong Kong University of Science and Technology (HKUST) and Visiting Professor of Industrial Engineering & Logistics Management Department at HKUST. He was Chair Professor 2005-2017 and also served as Department Head in 2001-2008 at HKUST. Before joined HKUST in 2001, he was Rockwell Chair Professor at Texas A&M University. He is a Fellow of the Institute of Industrial Engineers in U.S. and also a Fellow of Hong Kong Academy of Engineering Sciences.

**Thomas Runkler** received his MS and PhD in electrical engineering from the Technical University of Darmstadt, Germany, in 1992 and 1995, respectively, and was a postdoctoral researcher at the University of West Florida from 1996-1997. He is teaching computer science at the Technical University of Munich, Germany, since 1999, and was appointed adjunct professor in 2011. Since 1997 he is working for Siemens Corporate Technology in various expert and management

functions, currently as a Principal Research Scientist. Thomas authored and co-authored more than 150 scientific publications. His main research interests include machine learning, data analysis, pattern recognition, and optimization.

**Søren Salomo** is a professor for technology and innovation management and has since 2012 been head of department for DTU Management Engineering at the Technical University of Denmark. He has held previous positions at Graz University, TU Berlin and CAU Kiel. His research interests entail corporate innovation management with special focus on mechanisms for supporting highly innovative ventures and management of innovation project portfolios, organizational set-up for decision-making, and resource allocation in innovation projects. His work has been published in numerous recognized international journals and he is a lead author of a widely used German textbook on Innovation Management, now appearing in the 6th edition.



## APPENDIX 3: PROGRAMME OF THE SITE VISIT

### Program site visit IE & IS: 8-10 May 2017

Time	Part of the program	Attendees	Location
17.00-19.00	Pre-dinner meeting <ul style="list-style-type: none"> <li>Getting acquainted Committee members</li> <li>Purpose mid-term review</li> <li>First impression based on self-evaluation report</li> </ul>	Committee secretaries and	Inntel Hotel Art Eindhoven – room "Lichtzaal"
19.00-21.00	Dinner	Committee, secretaries, dean, vice-dean IE, vice-dean IS	Inntel Hotel Art Eindhoven – restaurant

#### 9 May: School IE and School IS - program morning

Time	Part of the program	Attendees
08.30-9.00	Welcome and introduction IE&IS	Frank Baaijens (rector TU/e) Ingrid Heynderickx (dean IE&IS) Jan de Jonge (vice-dean IE) Anthonie Meijers (vice-dean IS)
9.00-11.00	Preparation meetings with School IE	
11.00-12.00	Meeting selection of IE Professors and Associate Professors	Jan de Jonge (HPM – vice-dean IE) Pascale Le Blanc (HPM – associate professor) Eva Demerouti (HPM – full professor and group chair) Remco Dijkman (IS – associate professor) Uzay Kaymak (IS – full professor and group chair) Sjoerd Romme (ITEM – full professor and deputy group chair) Isabelle Reymen (ITEM – associate professor) Geert-Jan van Houtum (OPAC – full professor and group chair) Ton de Kok (OPAC – full professor)
12.00-12.30	Meeting selection of IE Assistant Professors and newly appointed Associate Professors	Josette Gevers (HPM – associate professor) Wido Oerlemans (HPM – assistant professor) Irene Vanderfeesten (IS – assistant professor) Pieter Van Gorp (IS – assistant professor) Ksenia Podoyntsina (ITEM – assistant professor) Bob Walrave (ITEM – assistant professor) Joachim Arts (OPAC – assistant professor) Arun Chockalingam (OPAC – assistant professor)
12.30-14.00	Lunch & reflection	

#### 9 May: School IE and School IS - program afternoon

Time	Part of the program	Attendees





14.00-16.00	Preparation meetings with School IS	
16.00-17.00	Meeting selection of IS Professors and Associate Professors	Yvonne de Kort (HTI – full professor) Chris Snijders (HTI – full professor and group chair) Wybo Houkes (P&E – associate professor and group chair) Anthonie Meijers (P&E – vice-dean IS) Floor Alkemade (TIS – full professor) Rudi Bekkers (TIS – associate professor and group chair)
17.00-17.30	Meeting selection of IS Assistant Professors and newly appointed Associate Professors	Daniël Lakens (HTI – assistant professor) Martijn Willemsen (HTI – associate professor) Philip Nickel (P&E – assistant professor) Sven Nyholm (P&E – assistant professor) Carolina Castaldi (TIS – associate professor) Johanna Höffken (TIS – assistant professor)
18.30 hrs	Dinner & reflection	Committee and secretaries

**10 May: PhD education school IE and school IS; future strategy IE&IS – program morning**

<b>Time</b>	<b>Part of the program</b>	<b>Attendees</b>
9.00-9.30	Meeting with Graduate Program directors	Paul Grefen (Graduate Program director School IE) Chris Snijders (Graduate Program director School IS)
9.30-10.00	Meeting with PhD students, including poster pitches (Paviljoen A 12a)	Meike Brehmer (ITEM) Christian van der Krift (ITEM) Afonso Sampaio Oliveira (OPAC) Loe Schlicher (OPAC) Yannick Balk (HPM) Inge Hulshof (HPM) Rick Gilsing (IS) Sander Peters (IS) Laura Huiberts (HTI) Alain Starke (HTI) Eva Boon (P&E) Marjolein Lanzing (P&E) Tanja Manders (TIS) Nick Verkade (TIS)
10.00-10.30	Meeting with PhD students School IE	Meike Brehmer (ITEM) Christian van der Krift (ITEM) Afonso Sampaio Oliveira (OPAC) Loe Schlicher (OPAC) Yannick Balk (HPM) Inge Hulshof (HPM) Rick Gilsing (IS) Sander Peters (IS)



10.30-11.00	Meeting with PhD students School IS	Laura Huiberts (HTI) Alain Starke (HTI) Eva Boon (P&E) Marjolein Lanzing (P&E) Tanja Manders (TIS) Nick Verkade (TIS)
11.00-12.00	Reflection and preparation next meeting	

**10 May: PhD education school IE and school IS; future strategy IE&IS – program afternoon**

<b>Time</b>	<b>Part of the program</b>	<b>Attendees</b>
12.00-13.00	Meeting with leaders research themes & management	Ingrid Heynderickx (dean) Jan de Jonge (vice-dean IE) Anthonie Meijers (vice-dean IS) Rudi Bekkers (leader Sustainability) Geert-Jan van Houtum (leader Logistics and its interfaces) Uzay Kaymak (leader Value of big data) Wijnand IJsselsteijn (leader Humans and technology)
13.00-15.45	Lunch, reflection & time for additional meetings	
15.45-16.15	Feedback to rector, dean and vice-deans	Frank Baaijens (rector TU/e) Ingrid Heynderickx (dean) Jan de Jonge (vice-dean IE) Anthonie Meijers (vice-dean IS)
16.15-16.45	Reflection	
16.45-17.00	Oral feedback of the recommendations to the Board, scientific staff members, PhD students and any other interested (Paviljoen K 08)	

## APPENDIX 4: QUANTITATIVE DATA

### School of Industrial Engineering

Research staff within the School IE (2010-2016)

	2010		2011		2012		2013		2014		2015		2016	
<b>Research unit</b>	#	FTE <sup>1</sup>	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>2</sup>	62	20.2	63	19.7	60	20.3	65	20.3	66	22.8	75	26.4	78	28.6
Postdocs	6	2.2	10	4.9	12	4.7	10	6.0	11	7.0	11	5.6	11	5.4
PhD students <sup>3</sup>	48		45		46		48		53		50		53	
PDEng trainees	17		26		25		30		27		21		22	
<b>Total research staff</b>	<b>141</b>	<b>22.4</b>	<b>144</b>	<b>24.5</b>	<b>143</b>	<b>25</b>	<b>153</b>	<b>26.3</b>	<b>157</b>	<b>29.8</b>	<b>157</b>	<b>31.9</b>	<b>164</b>	<b>33.9</b>

1. Research FTE, where research effort is a percentage of appointment. Standard ratio for Professors, Associate Professors and Assistant Professors is 40%; postdocs and PhD students 80%. For some of the researchers, this ratio differs from the standard.
2. Full, Associate and Assistant Professors; tenured and non-tenured staff.
3. Standard PhD (employed) and Contract PhDs (externally or internally funded but not employed).

School IE Funding (2010-2016)

	2010		2011		2012		2013		2014		2015		2016	
<i>Funding:</i>	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Direct funding <sup>1</sup>	6.1	75	6.2	74	6.3	69	6.2	65	7.0	66	7.8	69	9.0	75
Research grants <sup>2</sup>	0.1	1	0.1	2	0.1	2	0.2	2	0.3	3	0.3	3	0.6	5
Contract research <sup>3</sup>	1.9	24	2.0	24	2.6	29	3.1	33	3.2	31	3.1	28	2.4	20
<b>Total funding</b>	<b>8.1</b>		<b>8.3</b>		<b>9.0</b>		<b>9.5</b>		<b>10.5</b>		<b>11.2</b>		<b>12.0</b>	
<i>Expenditure</i>														
Personnel costs	7.6	90	7.6	93	8.0	91	8.3	90	9.0	88	10.0	89	11.1	93
Other costs	0.9	10	0.6	7	0.8	9	0.9	10	1.2	12	1.2	11	0.8	7
<b>Total expenditures</b>	<b>8.5</b>		<b>8.2</b>		<b>8.8</b>		<b>9.2</b>		<b>10.2</b>		<b>11.2</b>		<b>11.9</b>	
<b>Result</b>	<b>-0.4</b>		<b>0.1</b>		<b>0.2</b>		<b>0.3</b>		<b>0.3</b>		<b>0.0</b>		<b>0.1</b>	

1. Direct funding (lump-sum budget, shown in millions of euros)
2. Research grants obtained in national scientific competitions (e.g., grants from NWO and the Royal Academy)
3. Research contracts for specific research projects obtained from external organizations, such as industry, government ministries, European organizations and charitable organizations

Number of research products in selected School IE output categories

Type	2010	2011	2012	2013	2014	2015	2016	Total
Total number of ISI journal publications	75	81	97	78	102	95	93	621



Type	2010	2011	2012	2013	2014	2015	2016	Total
High-impact target journal articles	14	12	18	15	19	22	15	115
Percentage high-impact target journal publications compared to total number of ISI journal publications	18,7%	14,8%	18,6%	19,2%	18,6%	23,2%	16,1%	18,5%
ISI proceedings publications	37	11	26	21	20	19	18	152
PhD theses	18	7	14	14	12	9	9	83

## School of Innovation Sciences

Research staff within the School IS (2010-2016)

	2010		2011		2012		2013		2014		2015		2016	
Research unit	#	FTE <sup>1</sup>	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>2</sup>	44	15.5	42	14.8	41	14.2	42	14.4	38	12.7	45	14.3	47.0	14.9
Postdocs	12	9.0	12	6.6	11	6.6	9	5.9	11	4.4	8	5.0	10.0	6.0
PhD students <sup>3</sup>	36		34		28		26		30		36		35	
Other research staff	20	11.5	10	5.6	4	2.7	2	0.7	3	1.1	3	1.4	3	0.8
<b>Total research staff</b>	<b>112</b>	<b>36.0</b>	<b>98</b>	<b>27.0</b>	<b>84</b>	<b>23.5</b>	<b>79</b>	<b>21.0</b>	<b>82</b>	<b>18.2</b>	<b>92</b>	<b>20.6</b>	<b>95</b>	<b>21.6</b>

1. Research FTE, where research effort is a percentage of the appointment. Standard ratio for Professors, Associate Professors and Assistant Professors is 40%; postdocs and PhD students 80%. For some researchers, this ratio differs from the standard.
2. Full, Associate and Assistant Professors; tenured and non-tenured staff.
3. Standard PhD (employed) and Contract PhDs (externally or internally funded but not employed).

School IS Funding (2010-2016)

	2010		2011		2012		2013		2014		2015		2016	
Funding:	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Direct funding <sup>1</sup>	4.4	53	4.2	60	3.9	63	4.1	70	4.0	70	4.5	71	5.7	76
Research grants <sup>2</sup>	0.8	10	0.7	10	0.9	15	1.0	16	0.7	12	0.9	15	0.8	11
Contract research <sup>3</sup>	3.1	37	2.1	30	1.3	22	0.8	14	1.1	18	0.9	14	1.0	13
<b>Total funding</b>	<b>8.3</b>		<b>7.0</b>		<b>6.1</b>		<b>5.9</b>		<b>5.8</b>		<b>6.3</b>		<b>7.5</b>	
<i>Expenditure</i>														
Personnel costs	6.8	86	6.4	90	6.1	92	6.3	92	6.0	93	6.4	92	6.6	93
Other costs	1.2	14	0.7	10	0.5	8	0.5	8	0.5	7	0.5	8	0.5	7
<b>Total expenditures</b>	<b>8.0</b>		<b>7.1</b>		<b>6.6</b>		<b>6.8</b>		<b>6.5</b>		<b>6.9</b>		<b>7.1</b>	
<b>Results</b>	<b>0.3</b>		<b>-0.1</b>		<b>-0.5</b>		<b>-0.9</b>		<b>-0.7</b>		<b>-0.6</b>		<b>0.4</b>	

1. Direct funding (lump-sum budget, shown in millions of euros)
2. Research grants obtained in national scientific competitions (e.g. from NWO and the Royal Academy)

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

*Number of research products in selected output categories*

<b>Type</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>Total</b>
Refereed articles	68	81	89	91	78	85	63	555
Books	2	0	0	6	3	4	1	16
Edited volumes & special issues	6	1	7	5	6	5	5	35
Book chapters	57	23	29	27	21	26	15	198
Proceedings papers	17	25	23	20	26	16	16	153
PhD theses	7	4	9	8	8	9	8	53

