Assessment Committee Report on Research in Aerospace Engineering, 2007-2013 at Delft University of Technology

March, 2015

ASSESSMENT COMMITTEE REPORT ON RESEARCH IN AEROSPACE ENGINEERING, 2007-2013 AT DELFT UNIVERSITY OF TECHNOLOGY

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Title:
Assessment Committee Report on Research in Aerospace Engineering
2007-2013 at Delft University of Technology

Editors:
Prof.Dr.Ir. A. de Boer
Ir. S. Laudy

Quicken Management Consultants
Brinkstraat 286
7541 AV ENSCHEDE
info@quickenadvies.nl
www.quickenadvies.nl

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PREFACE

The Assessment Committee was assigned the task of evaluating the research carried out by eleven programmes in the Faculty of Aerospace Engineering at Delft University of Technology (DUT) over the period 2007 - 2013. On the request of the board of DUT the Standard Evaluation Protocol (SEP) 2015 – 2021 was used as guideline for the assessment.

The committee consisted of six experts being leading senior scientists in the field of Aerospace Engineering and covering all disciplines to be assessed. The assessment is based on a well written research report, key publications, miscellaneous information provided by the Faculty on the request of the committee, visits to the laboratories and interviews with the management, programme directors, PhD's, post-docs, tenured and non-tenured staff and the external Advisory Council. A draft of the assessment report was commented on by the Faculty board.

During the three day stay at the Faculty the committee had very good and open discussions with the motivated and enthusiastic staff members. The visits to the experimental facilities showed the impressive capabilities with which the students and researchers apply, evaluate and master theory. The interviews with the management team, dean and rector were also very positive and open and showed that the Faculty has a clear vision for the future.

The Assessment Committee would like to thank the Faculty for the thorough organisation of the visit and their hospitality during the stay. Thanks to this the three long and strenuous days were pleasant.

The Committee is convinced that the results of this assessment will be used wisely to further strengthen the position of the Faculty in the international field of Aerospace Engineering.

As chair of the Committee I want to thank the committee members for their valuable contributions to the assessment. Their broad and excellent knowledge in the field of Aerospace Engineering and the well prepared visit contributed to the

fruitful discussions before, during and after the interviews. Last but not least I want to thank Sven Laudy, the secretary of the committee, for the efficient preparation of the visit, taking the minutes during the interviews and writing the final report afterwards.

Prof.Dr.Ir. André de Boer
Chairman of the Committee

1. Assessment Committee and Assessment Procedures

1.1 Assessment Scope

The Assessment Committee was asked to assess the research of the Faculty of Aerospace Engineering at Delft University of Technology. This assessment covers research in the period 2007-2013. In accordance with the Standard Evaluation Protocol 2015-2021 for Research Assessments in the Netherlands (SEP), the Committee's tasks were to assess the quality, relevance to society, and viability of the research programmes on the basis of the information provided by the Faculty and interviews with Faculty management and research groups. Following this, the Committee was to make recommendations for the future.

1.2 Committee Composition

The members of the Committee were:

Prof. André de Boer (committee chair), professor of Applied Mechanics at University of Twente, The Netherlands;
Prof. J. Michael R. Graham, professor of Unsteady Aerodynamics at Imperial College London, UK;
Prof. Amy R. Pritchett, David S. Lewis Associate Professor in Flight Mechanics and Control, and Director of the Cognitive Engineering Center, Georgia Institute of Technology, USA;
Prof. Rolf Radespiel, professor of Fluid Mechanics at TU Braunschweig, Germany;
Prof. Christoph Reigber, emeritus professor at University of Potsdam, department of Geodesy, Germany;
Prof. Raimund Rolfes, professor of structural analysis at Leibniz Universität Hannover, Germany;
Prof. S. Mark Spearing, Professor of Engineering Materials in the Faculty of Engineering and the Environment at the University of Southampton, UK.

A short curriculum vitae of each committee member is included in Appendix A.

Ir. Sven Laudy of Quicken Management Consultants was appointed secretary to the Committee.

1.3 IMPARTIALITY

All Committee members signed a statement of impartiality and confidentiality to ensure that they would assess the quality of the research programmes in an impartial and independent way. Committee members reported any existing personal or working relationships between Committee members and members of the programmes under review before the interviews took place. The Committee discussed these relationships at the first Committee meeting. The Committee concluded that there exist no unacceptable relations or dependencies that could lead to bias in the assessment.

1.4 DATA PROVIDED TO THE COMMITTEE

The Committee received the following detailed documentation:

- Self-evaluation report of the unit under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices,
- Previous assessment report 2001-2006.

In addition, programme leaders provided hand-outs for each presentation.

1.5 COMMITTEE PROCEDURES

The Committee followed the Standard Evaluation Protocol, 2015-2021 (SEP). Prior to the Committee meeting, two assessors were asked to evaluate each programme. These assessors independently formed a preliminary assessment for each programme. Final assessments are based on documentation provided by the

Faculty, preliminary assessments and interviews. The Committee interviewed the Rector Magnificus of Delft University of Technology, the Faculty Management Team, the Faculty Advisory Council, and staff of the Graduate School and research programmes. Interviews took place on November 17, 18 and 19, 2014 at the Faculty of Aerospace Engineering in Delft. The interview schedule appears in Appendix B.

Before the interviews, the secretary of the Committee briefed the Committee on the Standard Evaluation Protocol for research assessments. This briefing covered the rating system (Appendix C). On the same day, the Committee discussed the preliminary assessments. For each programme, the Committee decided on a number of comments and questions. The Committee also agreed on procedural issues and aspects of the assessment. After each interview, the Committee discussed scores and comments. The Committee chair presented preliminary general impressions to the Faculty on the last day of the visit.

Following the on-site visit, the Committee finalised the report through email. Following approval by all Committee members, the Faculty received a copy of the first version for factual corrections. The Committee discussed these comments with changes to the report on a number of points. The Committee presented the final report to the Board of the University. This was printed after formal acceptance.

2. ASSESSMENT OF THE AEROSPACE ENGINEERING FACULTY

2.1 THE INSTITUTE

The Faculty of Aerospace Engineering (AE) aspires to deliver a valuable and distinguished contribution to society, therefore the Faculty strives to:

- Take a leading and internationally acknowledged position in the development of knowledge and techniques in the fields of aerospace, and related areas;
- Attract, inspire and educate students to become highly qualified engineers and scientists. Equip them with the knowledge, creativity and communication skills that are needed in a globalising and changing society;
- Develop knowledge and techniques for use in society and translate challenges from practice into research issues and solve these by building partnerships with industry and research institutes and by taking pioneering initiatives.

The Faculty of Aerospace Engineering has positioned itself to be a global player when it comes to tackling global challenges. The need for safe, clean and efficient air transport, as well as the need for innovative and reliable technologies for efficient space flight drives the exploration of innovative solutions for aerospace science and technology.

From December 2013 the Faculty of Aerospace Engineering consists of four departments that each host two or three research programmes:

- Aerodynamics, Wind Energy, Flight Performance and Propulsion (AWEP)
    1. Aerodynamics
    2. Flight Performance & Propulsion
    3. Wind Energy
- Aerospace Structures & Materials (ASM)
    4. Aerospace Structures & Computational Mechanics
    5. Novel Aerospace Materials

6. Structural Integrity & Composites

- Control & Operations (C&O)
    7. Aircraft Noise and Climate Effects
    8. Air Transport and Operations
    9. Control and Simulation
- Space Engineering (SpE)
    10. Astrodynamics and Space Missions
    11. Space Systems Engineering

The assessment takes places at the aggregate level of the eleven research programmes.

In the assessment period (2007-2013) AE aimed to increase their research impact through focus by stimulating high quality research through a stronger research effort in fewer research programmes. To this end AE followed five lines of action:

- Increase the research impact per programme by decreasing the number of research programmes and increasing the research effort;
- Attract, select and train for academic excellence, both for PhD-students and academic staff
- Update the state-of-the art research facilities – at the same operating costs;
- Collaborate with partners, both in the Netherlands, Europe and the rest of the world, and
- Stimulate technology and knowledge transfer to society, achieving success through cooperation and spin-offs.

REMARKS AND RECOMMENDATIONS

The self-assessment report shows that the Faculty has a clear strategy for stimulating and enhancing high quality research and education, following the five lines of action, and that also a strategy is developed for the further betterment of communications with the outside world and inside the AE and the TU-Delft. The overall impression is of a strong, confident Faculty.

The Committee considers the size of the Faculty and the fact that major fields of Aerospace are together in one Faculty a competitive advantage since they can combine research, provided that the departments and programmes collaborate well. The strategy to combine research programmes across and within the proposed departments is a good opportunity to increase this collaboration between the programmes and to use the limited research capacity efficiently. The choice of the composition of the departments is for AWEP, ASM and SpE a natural one. C&O, however, consists of new and more diverse groups. However, it is essential that the departments focus on a few research lines and all programmes contribute to these lines.

The Committee has seen many good examples of collaboration between the programmes as well as good contributions to the Faculty's overall goals. ATO seems to be less connected with other programmes and the Faculty as a whole, without a clear, consistent strategy as to how their group can collaborate with the rest of the Faculty. This needs close attention from the Management Team, since ATO could and should have an important added value in the Faculty.

2.2 QUALITY

Table 1 shows the demonstrable research output of the Faculty of Aerospace Engineering.

	2007	2008	2009	2010	2011	2012	2013
Refereed articles	111	140	185	172	182	156	198
Non-refereed articles	13	0	6	3	0	4	1
Academic books	3	4	10	6	9	2	6
Academic book chapters	19	15	27	34	52	22	26
PhD theses	14	14	26	27	33	22	32
Refereed conference papers	287	349	360	247	198	267	259
Non-refereed conference papers	0	1	1	4	6	6	3
Professional publications*	88	76	67	42	9	14	11
Popularising output**	3	10	2	6	10	10	7
Other research output***	52	54	98	40	38	65	72
TOTAL	**590**	**663**	**782**	**581**	**537**	**568**	**615**

Table 1: Total output Faculty AE

** professional publications: articles in professional journals, books, book chapters and conference papers, external reports*

*** popularising output: popularising books and book chapters, contributions to newspapers / magazines*

**** other research output: patents, book reviews, editorships, inaugural lectures, abstracts, appearances on radio or television*

REMARKS AND RECOMMENDATIONS

The Committee is overall very much impressed by the work. The quality of the research in the Faculty is high and research is diverse, which helps relevance and viability. The publication output shows a positive trend in 2013 with almost four refereed journal publications per research FTE per year (excluding PhD's). The current level of output is good and is highly visible.

The restructuring of the Faculty into four departments and eleven research programmes and the programmatic focus on three main themes has obviously

led to a significant increase in research outputs in the period from 2009 onwards. This concerns both the quantity of peer-reviewed articles – which are high – as well as completed PhD dissertations even though there was a reduction in the total funding over this period. The increasing number of publications in high-impact journals and the personal grants point to the growing importance and quality of the research programme activities. The performance metrics are in the range expected of a strong Faculty. Externally the Faculty is well regarded, and is widely thought of as one of the strongest in the field of Aerospace Engineering in the Western world.

2.3 RELEVANCE TO SOCIETY

The research conducted at the Faculty of AE is very relevant to society with much evidence of strong impact, particularly on industry. The Faculty is well known in the international aerospace community. The Faculty is involved in many European projects and is connected with major players in the industry, e.g. KLM, Boeing and Airbus, ESA, NASA. The Committee was impressed by the Advisory Council, which seems very much engaged even with its large number (25) of members.

The twelve spin-offs in the period under review are also a very good success and some earlier start-ups are now among the leaders in their areas, e.g. Actiflow, Advanced Lightweight Engineering, Airborne, , Flowmotion andISIS. .

Also AE is in close contact with policymakers at a national and international level and actively participating in several networks such as PEGASUS, ACARE and WG5 Resources.

In the efforts to valorise research the Faculty is supported by the TU Delft Valorisation Centre. Taking into account the amount of institutional funding that the Faculty receives there appears room for further improving the valorisation of research in a number of research programmes.

2.4 VIABILITY

The composition of the research staff at Faculty level is found in table 2.

	2007	2008	2009	2010	2011	2012	2013
	FTE	FTE	FTE	FTE	FTE	FTE	FTE
Tenured staff	20,7	23,4	23,3	24,3	24,9	27,6	30,5
Non-tenured staff	17,3	15,9	17,4	22	20,5	23,1	26,4
PhD candidates	56,4	62,9	77,7	84,2	86,2	110,3	110,8
Total research staff	**94,4**	**102,2**	**118,4**	**130,5**	**131,6**	**161**	**167,7**
Support staff	73,6	67,9	81,6	57,9	57,1	58,3	56,1
TOTAL STAFF	**168**	**170,1**	**200**	**188,4**	**188,7**	**219,3**	**223,8**

Table 2: Staff embedded in the Faculty AE

REMARKS AND RECOMMENDATIONS

Research staff

The Committee was impressed by most of the staff the Committee has seen. This is clearly the result of good hiring as well as a good system of developing young staff. At the same time the Committee considers that the Faculty may not be able to compete internationally for the best professors due to salary constraints. In the previous assessment teaching load was perceived as a major concern. During the site visit the Committee examined teaching load explicitly and observed that the teaching load for the scientific staff has reduced since the previous assessment although the inflow of students did not decrease. Currently, the Committee considers that teaching load is manageable in that it is not hindering research.

Strategy

The Committee is of the opinion that the Faculty has a good and solid strategy to continue as one of the leading Aerospace Research groupings in European and World universities for the next six years. However, the strategy for the next period seems not be as challenging as it could be. For longer term viability, the plans need to be more ambitious, with some higher-risk blue-sky research efforts

(e.g. “Space in 2030’s ideas” from SSE), of which the Committee saw too few examples during the site visit. See also the Faculty’s extra questions in section 2.7.

Leadership and governance

The written evidence gives the impression of a strong, confident Faculty, which is well led. The governance of the Faculty AE by the Management Team seems to perform well. This view was reinforced during the interviews where the Committee observed good team dynamics within the Management Team and between the Dean and the Rector. It showed a Dean on top of her job. The internal communication through the biweekly Management Team meetings with the Dean and using a twice a year meeting with all professors of the Faculty looks to be adequate. There seems some good personnel change within in the Management Team, each four or five years, which the Committee perceives as good.

Funding

Total funding declined over the years from €34.64 million in 2007 to €33.24 million in 2013. The percentage of direct funding increased from 70% in 2007 to 72% in 2013. The percentage of funding by research grants increased from 4% in 2007 to 5% in 2013, and the percentage of contract funding decreased from 25% in 2007 to 23% in 2013.

TOTAL	2007		2008		2009		2010		2011		2012		2013	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Direct funding[1]	24280	70%	23452	64%	20820	67%	21091	69%	21722	72%	23306	71%	23923	72%
Research funding[2]	1361	4%	1804	5%	1952	6%	1754	6%	1422	5%	1473	5%	1192	4%
Contract research[3]	8832	25%	11074	30%	8173	26%	7665	25%	6985	23%	7564	23%	7526	23%
Other[4]	170	0%	100	0%	225	1%	247	1%	185	1%	342	1%	602	2%
Total funding	**34643**	**100**	**36430**	**100**	**31170**	**100**	**30757**	**100**	**30314**	**100**	**32685**	**100**	**33243**	**100**

Table 3: Total funding at level of the Faculty AE. All amounts in k€.

1 direct funding by the University, obtained directly from the University, and the financial compensation for educational efforts.
2 research funding obtained in national and international scientific competition (e.g. grants from NWO, KNAW, EU/ERC, ESF)
3 research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.
4 Funds that do not fit the other categories

The Committee learned that the University is striving for a more stable money distribution to the Faculties, which seems to work. The Management Team has clear targets and common views on the funding. The Committee is impressed by the efficient way the resources are planned and divided up by the Faculty.

While the overall levels of research funding (per member of academic staff) appear reasonable the Committee sees some risks for viability. Firstly, there is considerable variation in funding levels between research groups. This may create issues regarding the viability of some areas, rather than the whole. Secondly, the Committee considers funding via research grants (very) low compared to contract research. Thirdly, at this moment a relatively high number of different research topics are covered. Based on the budget tables it is concluded that many 'small' projects are done, which has negative consequences for their efficient administration and also long term impact.

2.5 PhD programmes and Graduate School

In 2011 TU Delft started a Graduate School in support of doctoral education excellence. After a one-year preparation period, the Faculty of Aerospace Engineering launched the Graduate School of Aerospace Engineering as part of the TU Delft Graduate School. As of 1 January 2012, all new Aerospace Engineering PhD students had to enrol and meet the requirements of the Graduate School. The AE Graduate School offers a training programme aimed at preparing PhD students for their graduate studies; it improves their chances of finishing on time and prepares them for either an academic or an industrial career.

Remarks and recommendations

The number of PhD students that finish within 4 years was low in the past. Also, about 1/3 of students left without finishing their PhDs within a reasonable time frame. The foundation of the Graduate School can contribute to better performance on these metrics. The Committee is of the opinion that the Faculty has set up a convincing and pragmatic approach for the training of PhD's. The programme appears to provide a thoughtful mixture of individual course work, research participation, mentoring and progress monitoring. With the writing of a research plan within three months from the start followed with a qualifier after nine months, the guidance provided to PhD candidates is starting earlier in the process now, which the Committee considers great, also as it aids the breaking down of the old 'professor structure'.

In terms of number of PhD students the AE Faculty is also in a very healthy position. The introduction of the Graduate School with a clearly defined support and monitoring remit has further raised significantly the attractiveness of the DUT AE Faculty for PhD students.

From the interviews with the PhD-candidates the Committee learned that one of the reasons for the setup of the Graduate School was to establish a PhD-community. This community is not very much felt by the PhD-candidates since involvement in the PhD community is left to the individuals.

Sometimes it is not very clear to PhD-candidates how many papers are expected from them to graduate. Also, the Committee observed that some PhD's do a lot of teaching, which the Graduate School cannot influence. The Committee got the impression that there is discrepancy between the teaching target as experienced by some PhD's (about 20 to 25%) and the target level stated by the Graduate School (10 to 15%).

2.6 RESEARCH INTEGRITY

TU Delft strives to be articulate and explicit with respect to its ideals, values, principles and responsibilities and the means it utilizes to implement its vision in day-to-day practices, procedures and operations. TU Delft's integrity policy entails the 'Code of Ethics', several regulations and committees to support students and staff. TU Delft also has its own Scientific and Academic Integrity Complaints Regulations, which include a complaints procedure for situations involving breaches of scientific or academic integrity that may occur within the organisation. In 2012 and early 2013 TU Delft organised meetings with academic and support staff in which the Code of Ethics was discussed. At Aerospace Engineering additional meetings were organised with academic and support staff.

REMARKS AND RECOMMENDATIONS

The Faculty seems to take research integrity very seriously. There is an integrity policy which the TU Delft devotes significant effort to implement effectively. The Committee learned from the research staff that ethics is much more on the agenda and talked about than some five years ago, partly due to the monthly integrity meetings the Rector organises. In all interviews the Committee investigated integrity, but did not observe any issues in which integrity might be at stake. Most members of staff are very well acquainted with the integrity policy but staff that miss either the MSc-course or are not in Graduate School might be not fully informed about ethics, which was the case for some postdocs. Adding ethics in the introduction course for new staff could solve this one concern.

2.7 FACULTY'S EXTRA QUESTIONS[1]

CHOICE OF RESEARCH PROGRAMMES FOR ASSESSMENT

Extra question to the Committee: *"For the period 2007- 2013 the Faculty AE has chosen to take their research groups as research units for the research programmes to be assessed. Reason for this is that in the period that is assessed research was coordinated within these groups. Recently, the departments, consisting of several research groups, have become more important and are more and more the level at which research decisions are taken. For the next research assessment (which would cover the years 2014 - 2020) the Faculty is interested in what they think would be the best choice for research programmes to be assessed. The groups, the departments, or something else?"*

The Committee carried out the current assessment at the level of the research programmes. The new SEP prescribes a minimum of 10 FTE research staff which would preclude assessments at the level of the programmes. The Committee is of the opinion that an assessment on a higher / department level might not reveal the real issues on the group level. To be really able to assess the Committee needs to see the faces; for the assessment of research it is necessary to talk about research with the researchers. The Committee feels that assessing on departmental level will lead to a more organisational review instead of a research review and also will lead to a more global grading.

RESEARCH FACILITIES

Extra question to the Committee: *"The Faculty still heavily invests in its state of the art research facilities. This was an explicit decision, as we think that top notch facilities are needed to perform top research. However, you can spend your money only once. So this means that we cannot spend the money on additional academic staff, for example. What does the Committee think of the research facilities of the Faculty? And what would you recommend for a future strategy?"*

The Faculty has a range of facilities at the disposal of students, researchers and industry. The most notable are: the Cessna Citation II jet aircraft, wind tunnels, the Structures & Materials laboratory, the SIMONA Research Simulator, the

[1] The extra question on the Graduate School is discussed in section 2.5

CyberZoo, the Micro Air Vehicle Laboratory and the Clean room. The Committee considers these research facilities very good and appropriate. Many of the facilities are rather expensive but also unique. It gives the Faculty a competitive advantage. Investment should continue in these, as they are a strong 'selling point' of the Faculty's research.

The facilities absorb 11% of the total funding but this is well justified because it is used for research areas as well as MSc's and PhD's that fly out and spread the word of AE at Delft University of Technology. The figures show that the airplane is underutilised (only used for education). In the long run, if no more research programmes are going to use it, other ways of operating should be considered (e.g. with NLR) given the yearly costs. At the same time, further extending the aircraft's capabilities (beyond its current capabilities in testing new avionics and flight control) – e.g., to use the aircraft for atmospheric sampling or for aerodynamics or propulsion research – could be very expensive.

JUNIOR VS. SENIOR ACADEMIC STAFF

Extra question to the Committee*: "As described in the report the last few years the faculty has hired some highly talented additional junior staff, mainly tenure trackers. As a result the ratio of more junior academic staff (tenure trackers, assistant and associate professors) to senior academic staff (full professors) has become 4.3 to 1 at this moment. What would the Committee advise the Faculty for its future hires. Is there an ideal ratio junior versus senior staff? And what should we aim for?"*

The Committee learned from the interview with the rector that the University is moving away from pyramidal staff-system to a more balanced structure with more equal numbers of assistant, associate and full professors. This view is supported by the Committee, though the Committee also noted some mid-level staff were hired under the old system and would benefit from further mentoring about their potential advancement within the new system. Moreover, a lower junior:senior staff ratio has budget implications as junior faculty are promoted to higher-salary levels and more development of junior staff is required.

RESEARCH PORTFOLIO

Extra question to the Committee: *"The Faculty has always aimed at a well-balanced research portfolio. The current research portfolio is a result of tradition as well as specific strategic choices at certain points in time. What does the Committee think of the current research portfolio? Do we cover the right areas relevant for the future of Aerospace Engineering and Wind Energy? Is there anything missing?"*

The Faculty has a strong research portfolio. Historically it has been particularly directed at the aircraft industry and European space technology. Wind energy has become a very strong addition and it was the right decision some years ago to bring it into the Faculty. Because of cyclic variability in the aircraft industry the Faculty should continue to broaden its research areas. MAVs, UAVs, Green Aviation, Environmental impact, etc. are clearly growth opportunities, and further opportunities outside the aviation sector could be sought.

The new research portfolio, as presented in the self-assessment report, reflects well the described mission and objectives of the Faculty and the three grand themes- green aviation, miniaturization and planetary exploration. It also looks well balanced with respect to existing funding opportunities, the outstanding facilities of the TU Delft and the teaching and supervising obligations of the Faculty's research staff.

The project portfolio can also be broadened in a few areas. The Committee considers investing in a manufacturing chair a very good idea. Furthermore the research needs more systems-like research, which is necessary for the successful integration and commercial/social impact of their individual research findings. The right junior staff are also needed for this. The Committee feels that the foreseen TUD Wind Energy System professor should be part of the Wind Energy group and not placed elsewhere. Other examples of areas that are becoming more important and are not so well covered in the current research portfolio include avionics, software integration and a broad, pervasive approach to integrating safety requirements.

As mentioned earlier in the assessment report much of the safe “in-the-centre” research is conducted that is restricted to the Aerospace-field. The Committee recommends increasing more daring long term research across the portfolio, e.g. pull through of some of the novel materials technologies towards the system level. AE has the facilities and research capacity to allow at least some of the research activities to be higher risk with the potential for higher return. The Management Team and research group leadership needs to inspire at least some of the staff of the Faculty to adopt an attitude that enables this. The committee had the strong view that world leading contributions, which stand the test of time, are critical to maintaining and developing the reputation of the Faculty of AE, in the way that “Glare®” and the “cubeSats” have contributed to its current good international reputation.

Good examples of blue sky research are to be found in Space Systems Engineering and Novel Aerospace Materials.

3. ASSESSMENTS OF INDIVIDUAL RESEARCH PROGRAMMES

The Committee assessed the research programmes of the Faculty of Aerospace Engineering of Delft University of Technology. These are the programme level assessments:

Research Group	***Research quality***	***Relevance to society***	***Viability***
Aerodynamics	Very good to excellent	Very good	Very good to excellent
Flight Performance & Propulsion	N.A.	N.A.	Good to very good
Wind Energy	Very good	Very good to excellent	Good to very good
Aerospace Structures & Computational Mechanics	Good to very good	Good to very good	Good
Novel Aerospace Materials	Very good to excellent	Very good to excellent	Very good
Structural Integrity & Composites	Very good to excellent	Excellent	Very good
Aircraft Noise and Climate Effects	N.A.	N.A.	N.A.
Air Transport and Operations	Very good	Good to very good	Good
Control and Simulation	Very good to excellent	Very good	Very good
Astrodynamics and Space Missions	Very good	Very good to excellent	Very good
Space Systems Engineering	Good to very good	Very good to excellent	Very good

The detailed assessment of each programme follows.

3.1 RESEARCH PROGRAMME AERODYNAMICS (AERO)

Programme leader	Prof.Dr. F. (Fulvio) Scarano	
Research staff 2013	29.5 FTE	
Assessments	Quality	Very good to excellent
	Relevance to society	Very good
	Viability	Very good to excellent

The mission of the Aerodynamics group is to advance knowledge at a fundamental level and contribute in the early stage of conception and development of novel aerodynamic techniques. The objective of AERO is to explore innovative, potentially high risk ideas and develop these to a level of maturity that is relevant for technological innovation by industry. In their approach AERO combines state-of-the-art experimental and computational techniques, corroborated by theoretical modelling. The aerodynamic research is deployed with the broadest possible impact in mind, including applications for wind energy systems and the automotive sector.

Aerodynamic research methodologies are at the core of the group's activities. The three main sub programmes are Experimental Aerodynamics (EA), Computational Fluid Dynamics (CFD) and Applied Aerodynamics (AA).

The research staff is composed of 3.8 FTE tenured staff, 2.9 FTE non-tenured staff and 22.8 FTE PhD-candidates (2013).

QUALITY

The development of advanced flow diagnostics, advanced turbulence models and uncertainty quantification are complementary and relevant. The group's research output in terms of quality and quantity of articles in high impact journals (together with book contributions and conference proceedings) is excellent. The group's research has good international exposure and a large number of invited/keynote lectures have been given. The work in experimental aerodynamics (particularly flow diagnostics) has established a very strong reputation for this group. This is supported by significant CFD research. The group contributed in journals on PIV flow diagnostics that are clearly world

leading. The group also delivered some very good publications on computational aerodynamics. The Committee sees in this an extremely promising field, but the group is not yet leading here.

The applied aerodynamics research is very good but not as strong as the experimental research. Flapping wing technologies and plasma flow control is considered a small niche, and likely with a limited impact. Hence, flow control should be researched and applied in a broader context.

There is good staff representation on international boards/panels and the section has attracted high-ranking guest professors.

RELEVANCE TO SOCIETY

The relevance to society is very good. Flow diagnostics is widely being picked up. The links with industry are impressive considering the collaborations with ESA, DNW and Siemens among others. The group has major involvement in EU and other international projects, including coordinating roles.

The group contributes to public projects (sport aerodynamics etc.) through consultancy and access to the wind tunnels. There is significant membership of public boards and Committees (concentrated in a few members of staff). Articles are contributed to the public media.

VIABILITY

The management of the research group is doing very well. The Committee formed the impression that the head of the group is an integrative person and that there is a clear vision for the future. Uncertainty quantification in mathematical flow models and the integrated approach towards analysing experimental and numerical flow data are very promising and fruitful. The staff have a very good record on following up innovative ideas. Recently two good staff members departed which requires adequate succession planning and replacement of the individuals.

The Department has high quality wind tunnel laboratories with good instrumentation which are largely the responsibility of the aerodynamics group -

but are also used by other research groups in AWEP. 100-node computer cluster provision is also good for a group of this size.

The group has attracted a very good level of funding to support its research. There are no obvious problems of viability provided funding can be sustained. Therefore sustaining the group's leading position in flow diagnostics through innovative developments (e.g. assimilation of flow data with CFD) will be important.The Committee also suggests engagement with Airbus in a more structured way, preferably at Faculty level.

3.2 RESEARCH PROGRAMME FLIGHT PERFORMANCE & PROPULSION (FPP)

Programme leader	Prof.Dr.Ir. L.L.M. (Leo) Veldhuis	
Research staff 2013	17.1 FTE	
Assessments	Quality	N.A.
	Relevance to society	N.A.
	Viability	Good to very good

The group's mission is to conceive new and advance existing designs of innovative aircraft configurations and propulsion and power concepts through the exploration of:

- New technologies to obtain novel or improved solutions in specific areas in aircraft sub-systems;
- The advances in flight physics to improve the prediction and simulation of air vehicle performance;
- New methods and tools to improve the quality and effectiveness of the aircraft and propulsion system design process;
- Improvements in future propulsion, power and on-board energy systems.

The presentation made clear the research programme is based on two main pillars: engineering research and fundamental scientific research. The group is trying to feed the engineering research from fundamental research through five cross-fertilisation areas: propulsion integration, high lift systems, all electric aircraft, hybrid engines and Organic Rankine Cycles.

The Flight Performance and Propulsion group is the result of a reorganisation in 2011. The head of the section, Professor Leo Veldhuis, was appointed only recently, on 1 July 2013. Moreover, the other chair within the section, Professor Piero Colonna, who now leads the Power and Propulsion group, was appointed even more recently, on 1 September 2013. Since the FPP section has had no full professor in charge over the past years, the group will be reviewed only in terms of its viability.

The research staff is composed of 1.9 FTE tenured staff, 3.3 FTE non-tenured staff and 11.9 FTE PhD-candidates (2013).

VIABILITY

The areas of preliminary aircraft design including system technology assessment, propulsion integration; as well, internal propulsion flow and power systems bear potentially large synergies. It appears though, that not all necessary fields are yet covered by the qualifications of the present staff.

The potentials for research impact are significant in general. Accordingly, the written report and the presentation given to the Committee name a number of possible technologies which could make it into industrial products. However, this list appears partly vague, without much convincing detail as to the relative strength of the approaches followed by the section. The Committee sees the impact potentials of the section on the European level, whereas the national dimension appears rather limited.

The staff is composed of very experienced and young members. The two chairs seem both good leaders with high ambitions and a number of good ideas and a vision. It did not become totally clear to the Committee how the two programmes are interrelated and whether they can be integrated.

The Committee sees some risks for this newly established group. Firstly, the group is not very well funded yet, which is a risk for its viability. Secondly, the Committee perceives a risk of this group falling back into the traditional aerodynamics research area. Thirdly, there is a risk that the group will be too much seen as a service to other groups. Lastly, the future plans still generally extend over a very broad range of problems. The Committee is uncertain if the group can cover all the topics. If one or two are left out and some areas receive more attention, the group will still have relevant research to conduct.

The group has still to demonstrate that it can develop the needed knowledge and interdisciplinary collaborations to demonstrate synergies of advanced propulsion approaches on the overall aircraft level.

3.3 RESEARCH PROGRAMME WIND ENERGY (WE)

Programme leader	Prof.Dr. G.J.W. (Gerard) van Bussel	
Research staff 2013	11.1 FTE	
Assessments	Quality	Very good
	Relevance to society	Very good to excellent
	Viability	Good to very good

The mission of the Wind Energy group is to be at the leading edge of wind turbine rotor aerodynamic research as well as to be internationally recognised in the field of offshore wind farm research. The vision of the Wind Energy group is that wind energy engineering should, in the end, become as high-tech and mature as aeronautical engineering. The objective of the Wind Energy group is to be a leading R&D group in the fields of wind turbine rotor aerodynamics, loads on wind turbines, and offshore wind farm performance improvement.

The programme of the Wind Energy group mainly covers disciplines related to aerospace engineering. Other faculties of TU Delft cover additional disciplines in this field. That is why within TU Delft an interfaculty coordinating body is active, DUWIND, which connects the different disciplines spread across five faculties and its associated research groups. The Wind Energy group of the Faculty of Aerospace Engineering is the largest research group in DUWIND and it acts as the driving force behind the coordinating activities of DUWIND.

In order to achieve the strategic goals of the programme, the three following research lines have been implemented:

- External (wind) conditions for wind turbine loading
- Wind turbine aerodynamics
- Offshore wind farm optimisation

The research staff is composed of 2.5 FTE tenured staff, 2.1 FTE non-tenured staff and 6.6 FTE PhD-candidates (2013).

QUALITY

The research is well funded and clearly relevant. The group is well represented in international bodies. The group's research covers aerodynamics of both the rotor/turbine and its environment. In the past the bigger emphasis has been on the former but this is now changing to give more emphasis also to the study and representation of the wind environment including wakes and to wind park optimisation.. This is very relevant to wind parks (particularly offshore), which is where the industry now has a major focus.

The group has tended to have an emphasis on applied research in the past, which was commented on previously. It is steadily working to increase its proportion of fundamental research, including more PhD initiatives. The Committee notices that the group's outcome is increasing, however it does still need to increase the proportion of published output in high impact journals.

RELEVANCE TO SOCIETY

The research is highly relevant to society and the group has very good links and output to industry. There is significant involvement in national and European wind energy research programmes. The impact to industry was particularly high due to the research on and design of blade profiles, which are being used very widely throughout the industry now.

There is a strong cooperation with ECN, the main partner of the Wind Energy group. The Committee learned that ECN even has an in-house office at the Faculty. The WE group conducts the fundamental research and ECN does the applied research "selling", which seems to work.

VIABILITY

Being embedded in a very strong aeronautics department gives a reliable guarantee that access to high quality equipment and research students will continue. The close association with the aerodynamics group is also clearly beneficial. (Both of the above points also imply some dependency.) There will

undoubtedly be increasing competition for international visibility and research funds from the rapid increase in research into wind energy being built-up elsewhere in Europe and the world. The group is well supplied with high quality research equipment, particularly wind tunnels, through the group's position as a part of the AWEP Dept.

The organisation through DUWIND participation and leadership is very good. The group also seems to be well engaged in this Faculty. The Committee questions whether the group has enough resources to have a good viability for the next years.

The Wind Energy group needs to assess carefully with future developments in mind, the best research paths to follow to become a world leader in the field, taking account of the fierce competition in this field. The Committee suggests looking increasingly at (integration of) whole wind energy systems and not only aerodynamics, which is too much focussed. The Committee is of the opinion that the new DUWIND professor for Wind Energy Systems should be part of this group and should take a strong role in further increasing the visibility of DUWIND.

3.4 RESEARCH PROGRAMME AEROSPACE STRUCTURES & COMPUTATIONAL MECHANICS (ASCM)

Programme leader	vacancy	
Research staff 2013	11.4 FTE	
Assessments	Quality	Good to very good
	Relevance to society	Good to very good
	Viability	Good

The strategy of the ASCM group is to maintain and further develop their historic standing in fundamental and applied research in thin-walled lightweight structures and related fields. The dual mission of the ASCM group is to provide a high-quality education programme in mechanics and structural analysis and to lead innovative research activities in aerospace structures. The research focuses on the analysis, design, and optimisation of advanced structural systems and developing efficient computational methods and tools that are indispensable for solving critical technical problems relevant to aerospace engineering.

The current three strategic research areas of the ASCM group are:

- Structural Design Optimisation
- Stability and Vibration of Thin-walled Structures and
- Multi-scale Computational Mechanics

Very recently the Faculty has succeeded to find a new chair holder for the ASCM group. The new chair is expected in early 2015.

The research staff is composed of 1.9 FTE tenured staff, 2.6 FTE non-tenured staff and 6.9 FTE PhD-candidates (2013).

QUALITY

Generally the research quality of ASCM is good. The number of refereed articles and the number of PhD theses is high and the international visibility of this group in general is also high. However, the Committee missed the wow-factor. Structural Design Optimisation and Stability and Vibration of Thin-walled

Structures are very classical research areas, in which the Faculty gained a high reputation. It is a challenge to maintain such a high reputation. The research area Multi-scale Computational Mechanics is a result of integrating the former "Engineering Mechanics" group into ASCM and seems to be very promising for the future.

RELEVANCE TO SOCIETY

Research areas of the group fit well to the global research theme "Green Aircraft" of the Faculty. Due to the type of research, development of analysis tools, the contribution to society is not directly visible although the developed methods are applied in design environments. Most of the research is funded by external bodies. External parties at national (NLR) and international level (EU) frequently invite ASCM to participate in proposals for future research.

The group is also active in the recently started Delft Extension School, which will increase the impact and visibility of education and research for the Faculty and TU Delft.

VIABILITY

Strengthening of tool validation is an objective of the group. This is supported by the Committee. However, the Committee sees some risks for the viability of this research programme; since it is very much concentrating on continuing on the proven path. The Committee recommends more openness into new topics. Although the group seemed to work together well as a team, the lacking of a chair/leader was clearly visible e.g. with the delegation of quite junior staff during the site visit. The newly appointed chair has a clear scientific track record on experimental stability analysis. The Committee recommends to strengthen also other areas, especially in the field of multi-scale computational mechanics.

The Committee recommends to look at new research opportunities, e.g. multiscale analysis of composite materials and structures (from nanomechanics to structural analysis), aeroelasticity, wing morphing and flow control, or the linking of process and structural simulation (in cooperation with the new chair on manufacturing) which would be a good fit for this group.

External funding strongly depends on the EU. External funding for this group might become problematic. The group is aware of the fact that the funding is on the low end of Euro/FTE but is not concerned since they can carry out the research they want to. The Committee recommends the group to grow and diversify its funding.

The Committee learned that scientific collaboration with the research group Structural Integrity & Composites takes place; SI&C has a more fundamental focus while ASCM does more research with an engineering focus, especially in the field of fatigue analysis. At this time no common publications with the other group are issued.

3.5 RESEARCH PROGRAMME NOVEL AEROSPACE MATERIALS (NOVAM)

Programme leader	Prof.Dr.Ir. S. (Sybrand) van der Zwaag	
Research staff 2013	17.7 FTE	
Assessments	Quality	Very good to excellent
	Relevance to society	Very good to excellent
	Viability	Very good

The vision of the Novel Aerospace Materials (NovAM) group is that the field of aerospace engineering is a high-tech discipline in which increasingly new, and often multifunctional materials are required to enable novel aerospace design targets. It is the mission of the NovAM group to develop such materials, while not limiting themselves to solutions in only one particular material class. The NovAM group's objective is to be a leading science-based research group in the field of material development and at the same time to make their innovative concepts and insights available in such a manner that the industry can connect to their research.

The research lines cover four separate research fields: metals, polymers, self-healing materials & coatings and SMART materials.

The research staff is composed of 1.2 FTE tenured staff, 6.3 FTE non-tenured staff and 10.3 FTE PhD-candidates (2013).

QUALITY

Advanced materials, and the introduction of novel advanced materials is important to the Aerospace Sector. It is appropriate that such a group should exist within an Aerospace Engineering Faculty, and the Department of Aerospace Structures and Materials. The research conducted is of very high quality. Prof. Van der Zwaag is a top metallurgist, and is a leader in his field. The overall rate of publication and the academic impact of citations is strong. The group has a curiosity-driven research approach, which the Committee applauds, and are able to pick winners from it. The research carried out in the IOP Self-healing Materials programme is a good example of the latter. The Committee formed the impression that the research quality is better than the report shows.

RELEVANCE TO SOCIETY

Materials technology is very important to Aerospace and to society in general. Improved materials have an important role to play in reducing the environmental impact of aerospace (as per the Faculty's strategy). The relevance to society is very good and for some areas excellent. Some evidence for the relevance are listed here: NovAM is collaborating with many companies, both nationally and abroad, that are involved in the topic of self-healing materials. In 2013 TU Delft awarded Professor Van der Zwaag the honorary title of 'distinguished' professor in recognition of his achievement in connecting academia and industry in the field of materials. NovAM's work has resulted in about ten patents in the review period. A new high-performance liquid crystalline polymer developed in the NovAM group has been transferred to a technology accelerator start-up company. A joint development and licensing agreement (JDLA) has been signed with Eastman Chemical (US) with the aim to scale up the chemistry and target high-end aerospace and oil and gas composite applications. This is the first time in twenty years that a new high-performance polymer will be introduced into the market. The outcome of the research in the field of metals is directly fed into the steel production models of Arcelor-Mittal, the largest steel producer in the world.

VIABILITY

The importance of advanced materials to aerospace will not diminish for the foreseeable future. There is a risk associated with the small size of the group, which would make it vulnerable if a member of staff departs. The embracing of the manufacturing thrust is appropriate, and there are good opportunities for impact (and funding) at the interface of novel materials and advanced manufacturing.

The group is very strong and has a clearly strategic intent with focus on aerospace related research only. The Committee formed the impression that the leader has good organisational capacities and is a strong leader. The Committee noted this chair is not part of the Faculty's Management Team, but would certainly have the capability to provide senior leadership within the Faculty.

The technical coverage of advanced materials (which is very broad) is limited by the relatively small size of the group. The funding level is good

(~190k€/academic/year), and diverse, with government and industry funding in evidence. EU funding was less evident. The group seems to be able to access the appropriate equipment to conduct its research.

The group is well connected to collaborative partners and the Committee observed a good strategic fit between group and Faculty. The idea of investing in a manufacturing chair is supported by the Committee. The rate of PhD supervision seems slightly low for this area (~0.4/academic/year). The Committee is of the opinion that more than two full professors are needed for this group. With a relatively small group the viability can be at risk, if some of the leading researchers leave. In this respect, the Committee recommends to invest in personal development for this group, in order for leadership to be more widely distributed, with the aim of making the group more robust.

3.6 RESEARCH PROGRAMME STRUCTURAL INTEGRITY & COMPOSITES (SI&C)

Programme leader	Prof.Dr.Ir. R.(Rinze) Benedictus	
Research staff 2013	21.9 FTE	
Assessments	Quality	Very good to excellent
	Relevance to society	Excellent
	Viability	Very good

The vision of the Structural Integrity & Composites (SI&C) group is that the field of aerospace engineering is a high-tech and multi-disciplinary field in which a holistic approach, founded on the application of science, mathematics and engineering principles, is needed to successfully introduce new materials, new processing methods and new structural concepts to realise the ambitious "FlightPath 2050" goals as described by ACARE.

The mission as an integral member of the Faculty of Aerospace Engineering is to carry out research and development programmes that will result in new methods and tools that will support the European aerospace industry and other fields where structural integrity and low structural weight are essential. It is the objective of the SI&C group to be a leading research group, bridging the gap between materials and structures oriented communities, fundamental science and applications.

The current research fields within SI&C are: Fatigue and Damage Tolerance, Structural Health Monitoring, Non-Destructive Testing/Inspection, Manufacturing and Structural Design.

The research staff is composed of 2.7 FTE tenured staff, 2.3 FTE non-tenured staff and 16.9 FTE PhD-candidates (2013).

QUALITY

Structural integrity and composites is a key area of technology for modern aerospace systems. Reducing the cost of operating vehicles and the increasing use of composites for weight reduction are major trends in current aerospace

and are likely to persist through the next decade. The objectives of the group are sound. The topics chosen for research are sensible. Fatigue and damage tolerance, Structural health monitoring, NDI/T and Manufacturing and Design are all important drivers for modern aerospace.

The research outputs are of very good quality and the group is well respected. There has been a significant loss of senior staff, but the group has recruited well and is well placed to be one of the leading groups in this area. The group seems to be well supported by laboratory facilities. The publication rate (~5/academic/year) is good. These papers seem to have reasonable academic output. The senior members of the group are well regarded in the scientific and technical communities.

Good numbers of invited papers, chair and membership of conference committees indicate the Group's strong reputation nationally and internationally.

RELEVANCE TO SOCIETY

The work conducted is important to the aerospace sector, and will thus have impact on safety and the economics of the sector as a whole. There are good links to industry, which will ensure the take up of the research outputs. Most notable amongst these, the research group has generated significant impact, especially concerning the use of "Glare®" in the A380, in conjunction with Airbus. The patent portfolio is impressive.

The research group has acquired and fitted out over the assessment period a state-of-art fully equipped lab. In addition other (older) test and specimen fabrication equipment is still available for use. Equipment which has become less used has been lent or given to industrial partners.

VIABILITY

SI&C is a very good group that is very well led. The group is well staffed. The group has invested in earlier career members of academic staff, so these people should grow as contributors and then leaders over the next evaluation period. However the ratio of senior to junior staff is quite low and an increase of this ratio may be advised. The rate of PhD supervision is good (~0.7/academic/year).

The topics under investigation by this group will remain of importance. The group is very well-funded (~520k€/academic/year) and there is good diversity of funding streams. There is a good level of funding from industry.

To move from a rating of very good to excellent, a portfolio of new ideas – e.g "a new Glare" - are necessary. The Committee recommends that the group invest in some more radical new ideas in order to ensure that it will have a high viability in five years from now, rather than just keep going in the current area. Also the Committee suggests that it would be appropriate to strengthen the systems approach that is needed in this area. There are opportunities for increased interdisciplinary work with the AWEP and C&O departments, both at the whole vehicle level and in work on systems, such as structural health monitoring or approaches to active flow control.

3.7 RESEARCH PROGRAMME AIRCRAFT NOISE AND CLIMATE EFFECTS (ANCE)

Programme leader	Prof.Dr. D.G. (Dick) Simons	
Research staff 2013	N.A.	
Assessments	Quality	N.A.
	Relevance to society	N.A.
	Viability	N.A.

The vision of ANCE is that in order to achieve sustainable growth in aviation in the next decades while decreasing the impact on the environment, more accurate models for predicting the noise footprint and climate effects are required. ANCE's mission is to contribute significantly to the development of these models through strong national and international collaboration and to use the models for noise and climate studies. It is the objective of ANCE to become an internationally recognized research group in the field of environmental effects of aviation within the next four years.

Within ANCE the focus will be on the following three research sub-areas:

- Detailed aircraft noise source modelling for assessment of new aircraft technologies
- Weather-dependent noise contour modelling
- Studies of the effects of aircraft emissions on climate change

The Aircraft Noise and Climate Effects (ANCE) was created in 2014, due to growth within the Air Transport and Operations (ATO) section and a desire to better exploit opportunities in the areas of aircraft noise and climate effects. Since the ANCE group started in 2014 and plans and strategy are premature yet, only *qualitative* remarks on viability are given.

VIABILITY

The research field of this group is important and growing. At the same time the Committee feels that some topics of climate effects have been in the spotlights for some time, and ANCE is not ahead of international developments yet. Many institutes are conducting research into this topic nowadays and competition is fierce.

The objectives, particularly regarding aircraft noise research, are good. The plans for research into climate effects need to be expanded. The Committee is of the opinion that currently the group is missing a unique selling point to set them apart from other institutes.

The organisation of the group clearly is in its early stages and should develop as the research group size increases. The group is now too small and growth is necessary to become a global player in this area. The Committee learned that ANCE is attracting a new full professor, which is a necessary (but perhaps not sufficient) step as the group is very resource-challenged and have to bring in many people from outside, which implies risks to its continuity.

Also a strategic fit and further connections should be sought with other research groups, for example with ATO and ATM in the C&S group and with respect to aircraft noise source modelling could fit with the department AWEP.

Relevance to society has the potential to be considerable but is still developing. The VCNS is an interesting development with NLR, and the planned workshop is also a very positive step. Collaboration with outside research institutes/groups is established but no definite proposals for funding research are indicated yet. The committee recommends setting up collaboration in the field of noise source localisation with experienced research groups outside the aerospace discipline.

The Committee concludes that it sees opportunities for ANCE in this important area but that the viability for this newly established group depends on expansion of the group (staff and infrastructure) and a strategy with a clear unique selling point. The Committee considers that the Faculty will need to give strong commitment and support to the group to make it successful and leading in the topic.

3.8 Research Programme Air Transport and Operations (ATO)

Programme leader	Prof.Dr. R. (Richard) Curran	
Research staff 2013	10.0 FTE	
Assessments	Quality	Very good
	Relevance to society	Good to very good
	Viability	Good

The vision of Air Transport and Operations (ATO) is to ensure integrated and sustainable performance in air transport. Their mission is to develop multi-objective and multidisciplinary analysis and optimisation methods to achieve efficient integration and sustainable air transport. The objective of ATO is to develop a value-based operations modelling approach coupled with socio-technical systemic analysis, with particular reference to capturing the airline perspective.

ATO has three strategic research aims:

- To develop radical new ways to optimise aircraft-centric operations for operational efficiency, safety, cost-effectiveness and minimal noise and environmental impact
- To extend the aircraft-centric performance analysis to an airline fleet and network level while expanding this analysis to include capacity and resilience to disruption
- To synthesise points 1 & 2 to include operational performance and safety at airline and Air Traffic Management (ATM) level in the socio-technical domain.

The research in ATO has been organised into three research lines: Flight Operations, Air Transport Safety and Airline Operations.

The research staff is composed of 3.1 FTE tenured staff, 1.0 FTE non-tenured staff and 6.0 FTE PhD-candidates (2013).

QUALITY

Air Transport and Operations is an important area that aligns well with the Faculty's strategy. It has an important part to play in ensuring the sustainability of air transportation for the decades to come. The group's objectives are strong. The research quality of the individuals leading the three research areas is very good. The rate of publications is reasonable, particularly considering the turnover of staff. Similarly the number of PhD starts and graduations is good under the given circumstances.

RELEVANCE TO SOCIETY

The research carried out seems to be of high practical relevance. Prof. Curran is well connected to industry and government agencies. The links with NLR (Dutch Aerospace Laboratory) are very strong. One day a week ATO has Professor Blom from the NLR as a visiting professor. The established links to government and industry are a clear path for achieving and demonstrating such relevance. The group is well placed to carry this through. A lot of interactions take place with Schiphol and KLM. The Committee recommends broadening the network beyond these single points within the industry, however. The group developed many models and tools in the period under review that are used in industry and by policymakers at Eurocontrol. An example is the developed software tool Amust used by the Dutch Ministry of Infrastructure.

VIABILITY

The Committees noticed the research appears to be quite focused on three people who lead three areas. The senior staff members have a huge network that should be opened up to the whole research group. The Committee sees some management challenges for the group to make this commitment to the junior researchers since the senior staff need to devote sufficient attention to winning research funding. The group should develop a strategic plan for the development of the junior staff, including ways of opening up the network to the young staff.

While the external collaboration seems adequate, the collaboration with other groups within the Faculty seems limited, and the committee had the strong impression that ATO is driving away from the rest of the Faculty. Regarding the latter: no evidence was provided in the written submission, or during the

interview to indicate any significant links with the rest of the Faculty. In our view regarding the potential to exploit synergies across the Faculty by tackling system-level problems, ATO has strong potential to play a key role.

The Committee is of the opinion that the four research lines that cross the three sections span a broad range of topics for the size of group. Although the strategy and focus areas are sensible the reality of its implementation was confusing to the Committee, and it's not clear if all the lines and sections are actually being addressed and integrated. The Committee considers that if a clear mission and coherent vision is executed, there should be a much stronger activity by the next evaluation.

The Committee is not sure they need a full-blown supercomputer as suggested in the report, but some sort of compute cluster can, nowadays, be established at reasonable cost (or, the group might purchase access to computing resources at a marginal rate), as well as further investigating DUT computing resources that they may be able to apply.

3.9 RESEARCH PROGRAMME CONTROL AND SIMULATION (C&S)

Programme leader	Prof.Dr.Ir. M. (Max) Mulder	
Research staff 2013	26.5 FTE	
Assessments	Quality	Very good to excellent
	Relevance to society	Very good
	Viability	Very good

The vision of the section Control and Simulation is that reaching for ever-increasing levels of safety, efficiency and capacity of aeronautics will require developing more capable automatic control systems in terms of adaptability and autonomy, and more advanced human-machine interfaces to interact with them. Their mission is to advance the development of such systems, building on a solid theoretical basis and physical insights while exploiting theoretical progress in adjacent fields, and to validate these systems experimentally in world-class facilities, thus closing the loop between theory and practice. It is the objective of Control and Simulation (C&S) to be a leading research group in the integration, development and testing of new theories on control, autonomous systems and cognitive systems (with and without human elements), while addressing industrial and societal needs.

In addition to the two existing research lines, aerospace guidance, navigation and control (AGNC), and aerospace human machine systems (AHMS), C&S has initiated a third theme that focuses on the emerging field of unmanned Micro Aerial Vehicles, (MAVs). In April 2013 a new professor was appointed in the group, who will start a fourth theme: Communication, Navigation & Surveillance in Air Traffic Management (CNS/ATM). The latter was not under review by the committee, due to the very recent appointment.

The research staff is composed of 6.7 FTE tenured staff, 0.0 FTE non-tenured staff and 19.8 FTE PhD-candidates (2013).

QUALITY

The C&S research programme is at high level internationally partly due to its model based perspective. This, in combination with the group´s ability to test and refine theoretical results and new concepts in top-class laboratory infrastructure (Cessna Citation Laboratory aircraft, SIMONA flight simulator and MAV lab) has triggered high recognition of the C&S research in the European as well as international aerospace control and simulation community.

The programme is unique for including a focus on human-machine systems interaction and manual control far beyond any other leading aerospace school in the world. Overall, its research objectives are superlative.

The impressive progress achieved in the three research themes, particularly, includes a steadily increasing number of journal publications since 2009, a constant high publication record in conference proceedings over the whole period and an improved number of PhD theses and prizes.

The group has won many awards as a demonstration of its research quality. Overall this group is clearly very strong.

RELEVANCE TO SOCIETY

Advancements in aerospace guidance, navigation and control and human-machine interface research are of great importance for improved flight operations, flight security, reduction of operators' workload etc. All this, together with the progress in designing autonomous small-scale MAVs is clearly of high societal and economic relevance.

This group does have the unique capability to enable UAVs, and to examine the relative role of the human on the machines' performance. The Committee recommends that it uses its considerable collective capability to work to transition theory more into societally relevant applications.

The relevance and impact on the aviation industry might also be increased if C&S reached out more (at least more than was apparent in the report) to broader areas – training of the pilots (and other expert operators such as air traffic controllers) and policy are two potential areas for consideration.

VIABILITY

The organisation of the group is fine. C&S has a strong and vital group activity, clear well-defined goals and targets for the next five years, very good prospects, good leadership, a solid staff and is highly attractive to talented new academic staff. The Committee suggests hiring a few tenure-trackers since currently the group has none, which seems a missed opportunity for a group of this size. For sustainability, it is important that junior staff demonstrate that they can attract and publish research on their own, in addition to the current trend of research publications that appear to be managed by the senior staff and programme leader.

The networks in academia and industry seem established. A high portion of the work is done in collaboration with a variety of academic and major industrial partners, but also with SMEs and start-up groups. The Committee observed no connections between this group and ATO, which is curious – perhaps driven by historical interactions within the relevant researchers – that the new professor in Air Traffic Management is in this group rather than in the ATO group. This new professorship will strengthen the C&S group, but to an outsider the lack of obvious connection does look odd and, as noted in the discussion of the ATO programme, it is important to at least establish appropriate collaborations between these programmes.

With an average of about 200k€ per academic per year the funding levels are quite appropriate for the volume of work produced.

3.10 RESEARCH PROGRAMME ASTRODYNAMICS AND SPACE MISSIONS (AS)

Programme leader	Prof.Dr.Ir. P.N.A.M. (Pieter) Visser	
Research staff 2013	14.7 FTE	
Assessments	Quality	Very good
	Relevance to society	Very good to excellent
	Viability	Very good

The research portfolio of AS covers the complete cycle of satellite missions: from concept to application, and from launch to end-of-life. The aim is to provide data, models, methods and tools to demonstrate and exploit the unique capabilities of spaceflight. The research covers a broad range of scientific and societal issues ranging from global change to participating in interplanetary missions searching for extra-terrestrial habitats.

The core research themes are astrodynamics and space missions with the sub programmes

- mission analysis, orbits, engineering
- space propulsion, ascent and re-entry trajectories
- planetary exploration

These sub programmes support the research priorities of the SSE programme (distributed space systems and miniaturisation) and the Faculty's research priorities (sustainability, miniaturisation and exploration of our solar system).

The research staff is composed of 5.3 FTE tenured staff, 3.8 FTE non-tenured staff and 5.7 FTE PhD-candidates (2013).

QUALITY

The AS research programme core themes are Astrodynamics and Satellite Systems, themes which are in parts closely connected and are of crucial importance for observing and monitoring the Earth with near Earth orbiting space craft and exploring our solar system with deep space probes. For the

handling of the sub programmes Mission analysis, orbits, engineering, and Space propulsion, ascent and re-entry trajectories the AS group has demonstrated an outstanding and internationally highly acknowledged expertise over a period of many years. For the area of planetary exploration AS created a new capacity group for studying planets and moons, headed by a highly respected expert in the fields of geodynamics and planetary sciences. The work of this group is, besides the geo- and planetary physics aspects, strongly dependent on the expertise of sub programme Mission analysis, orbits, and engineering capability.

The great strength of the AS multidisciplinary research programme is its clear focus towards new scientific and technological developments and requirements in Earth system- and planetary sciences and its proper balance of fundamental and application-driven research activities. All three sub programmes interact in a remarkable way to carry out the required research and have good working connections with the SSE programme.

AS sub programme leaders have a very high to excellent reputation in the international community and the research quality of the scientists in the AS programme is at a very high level internationally. This is reflected in the good number of peer- reviewed articles in journals with high impact and the substantial representation of group members in ESA advisory bodies, international scientific services and national organisations. However, the number of PhD students is a serious point for improvement.

RELEVANCE TO SOCIETY

The ambitious goal of the AS team is to cover appealing and innovative research aspects within the broad range of scientific, application oriented and societal issues ranging from global change to interplanetary mission issues. Internationally highly recognized research results and radar altimeter and atmospheric density and wind data bases, derived by the group from various near-Earth satellite missions, are of high relevance for the aforementioned societal issues, for international research groups and for the Faculty´s topical themes.

VIABILITY

The viability of the AS research programme is reflected by the growing research output over the course of the evaluation period (e.g. number of referred articles) and with its many contacts the group is vibrant and very present on the European and international scene. It is a well-respected partner in many research consortia and collaborations in Europe and worldwide.

Research is supported by state of the art computer and software infrastructure. The need for GPS ground receiver equipment support in the AS group is questionable.

The area of planetary exploration is new to this group. With only one PhD on the topic this seems too low a number to become leading. The Committee considers the number of PhD's for the group as a whole also too low and recommends increasing the numbers in the years to come.

The funding level acquired by the group through grants and contracts is substantial (accounting for about 13% of the overall Faculty´s acquisitions), particularly considering the high levels of competition and ongoing reduction of the budget for single project calls and the need to share smaller budget within project consortia.

The Committee considers the broad range of activities of the group represents a risk since maintaining critical mass and the required core areas of expertise, could become a problem.

In collaborating the group is leaning heavily on the good connections they have with NLR and DLR but there are many other groups that are interesting to which the group could extend its network to. In the field of Aerothermodynamics the Committee suggests that AS should work more together with the Aerodynamics group. During the interviews the Committee learned that a PhD is starting in a field overlapping both AS and AERO and this is encouraging.

3.11 RESEARCH PROGRAMME SPACE SYSTEMS ENGINEERING (SSE)

Programme leader	Prof.Dr. E.K.A.(Eberhard) Gill	
Research staff 2013	8.1 FTE	
Assessments	Quality	Good to very good
	Relevance to society	Very good to excellent
	Viability	Very good

Research at the Chair of Space Systems Engineering (SSE) is recognized for its enabling competencies within space engineering. The research objective of SSE is to advance enabling competencies within space engineering through innovation power and knowledge generation. Based on the group's research and engineering capabilities, enabling technologies are developed, characterised or used to satisfy societal needs. Enabling technologies offer new functionalities, increased performance or improved economics for space systems.

SSE's research strategy is to realise complex space systems in an end-to-end engineering approach. This approach captures stakeholder needs and covers design, development, integration, verification validation and operations of entire space systems. Such space systems can be CubeSats, a class of highly miniaturized satellites in the mass range of a few kilograms.

The SSE research programme focusses on two quite novel space system related research areas: Miniaturisation and Distributed Space Systems.

The research staff is composed of 1.4 FTE tenured staff, 1.8 FTE non-tenured staff and 4.9 FTE PhD-candidates (2013).

QUALITY

The success of the Delfi CubeSat and of other Micro/NanoSat mission programmes in which the group has participated speaks for itself. The production of working satellites by a University research group is impressive and is a testament to the strength of the systems engineering expertise within the group. The Delfi mission programme is the group´s flagship and an

internationally highly recognized contribution for further developments in the CubeSat and other miniaturized spacecraft domains.

Although the group increased its publication output, the scientific research outputs are slightly disappointing, particularly in journal paper publications, at less than one paper per member of the group per year, which is low compared to other groups. The group might be advised to pay attention to extracting underlying or cross-cutting lessons from the particular "design-build" projects they are engaged with. It is acknowledged that relatively low journal publication rates are consistent with more application-focused fields of engineering, but, nevertheless, the Committee felt that there was room for improvement. Prof. Gill has a good level of external visibility and engagement and is clearly well respected in his field. The other members of the group are developing external recognition appropriate to their levels of experience.

RELEVANCE TO SOCIETY

Any successful satellite mission creates increased attention of at least the national media and through these increases the awareness of the public regarding the significance and societal and scientific value of new technology. Fleets of miniaturized satellites are very likely the most effective way for future continuous monitoring of our environment. Satellites of the Delfi class are the pathfinders in this direction and have acquired high levels of visibility and therefore the relevance of this research area is high. This and the appeal of miniaturized technical tools has good potential to motivate an increasing number of young people to study engineering and sciences subjects and will help to influence the research agenda of national and international agencies, institutions and government bodies.

VIABILITY

Space systems engineering will continue to be an important area within aerospace for the next review period. This is a vibrant time for small satellite development, and the range of missions and applications is increasing.

The group has developed a clear strategy and roadmap for the further development of the section´s (long term) programme. In this respect the Committee applauds the blue-sky project OLFAR.

The coherent research and development programme, carried out by a small highly motivated group of tenured/non-tenured scientists and a growing number of PhD students, has allowed the SSE section to become one of the few academic groups worldwide who successfully develop and operate CubeSats carrying innovative technology. The SSE group leader and his staff members cover most of the key areas of the programme. Insufficient experience in specific areas is filled through close cooperation with the AS and CS sections, other AE departments and other TU Delft facilities. The group is making wide use of its innovation capacity.

A prerequisite for the development, integration and test of space system hardware is the availability of a high class cleanroom. The class 100,000 cleanroom AE facility fulfils these tasks and is also used for education. Besides the cleanroom the SSE group has established additional test facilities.

The direct funding of section staff looks quite limited and the acquired external funds are low over the whole evaluation period. During the interviews the Committee learned that funding is recognised by the group as being a key concern. One of the group's strategies for increasing funding levels is to focus on fewer research areas.

The group is well-connected to other groups within the Faculty and elsewhere at TU Delft e.g. with the Faculties Mechanical Engineering, Electrical Engineering and Civil Engineering & Geosciences. The Committee considers it very important to connect even better with Electrical Engineering.

As a concern for its viability the Committee observed an enormous base of technological engineering "know-how", but that this is underpinned by relatively little unique engineering science capability, therefore, there is a risk that the group could lose its leadership position, as others acquire similar practical know-how. The Committee learned that the group is aware of this risk and as a result hired many PhD's to cope with this challenge.

APPENDIX A CURRICULA VITAE OF THE COMMITTEE MEMBERS

Professor André de Boer studied Mechanical Engineering at the University of Twente and graduated in the field of tribology. In 1979 he joined the department of Anatomy & Biomechanics of the Vrije Universiteit and started in 1981with a PhD research at the department Dental Physics at the State University Utrecht. In 1987 this resulted in a PhD degree with the thesis 'Mechanical modelling and testing of the human periodontal ligament in-vivo'. In 1985 he joined the National Aerospace Laboraory (NLR) to work on the dynamic behavior and stability of aerospace structures. Later he was involved in projects on thermo-mechanical analyses of gasturbine components and acoustics. In 1997 he became leader of the Structural Mechanics group at the NLR and in that period he was also involved in the Glare certification program. In 2000 he was appointed to professor at the chair 'Technische Mechanica' at the University of Twente. There he teaches students Mechanical Engineering and Industrial Design Engineering structural mechanics and carries out research in the field of structural dynamics and acoustics. Since 2012 he combines the function head of the section Applied Mechanics with that of director of the BSc and MSc Mechanical Engineering programmes.

Professor J. Michael R. Graham obtained a BA degree in Mathematics at the University of Cambridge in 1963, part II Engineering at the same University in 1964, followed by a PhD in Aeronautics at Imperial College London in 1968. He was appointed to a lectureship in the Aeronautics Department at Imperial College in 1970, becoming Professor of Unsteady Aerodynamics in 1990 and Head of Department from 1999 to 2003. Since 2007 he has been a Senior Research Investigator in the same Department. He is a fellow of the Royal Aeronautical Society (1995) being a member of the Aerodynamics Committee (1990 to 2007) and chair of the Accreditation Committee (2008 to 2011). He is also a fellow of the Royal Academy of Engineering (2006) and of the Royal Institute of Naval Architects (2007). He was formerly on the editorial board of the Journal of Fluids and Structures (1986 to 2007) and is since 2007 chair of the editorial board of

the Aeronautical Journal. He has also been a member of the Engineering and Physical Sciences Committees for High Performance Collaborative Computing and for the Oil and Gas Extraction Programme, and the Department of Trade and Industry Advisory Committees for Hydrocarbon Additional Recovery Research and for New and Renewable Energy. His research interests include Renewable Energy (Wind Turbine Aerodynamics, Coordinator of the EU Joule II project ROTOW, and Tidal Stream Turbine Hydrodynamics), Wind Engineering and Environmental Flows (particularly Aero-elastics of Suspension Bridges), Marine Technology (Wave forces on Offshore Structures, Vortex-Induced-Vibration of Marine Riser Pipes and Hydrodynamic Damping of Floating Bodies, managing agent of EPSRC directed programme on Marine CFD), Turbulence and Numerical Simulation of Vortical Flows and Wakes.

Professor Amy R. Pritchett is the David S. Lewis Associate Professor of Cognitive Engineering in the School of Aerospace Engineering, Georgia Institute of Technology. She holds a joint appointment in the School of Industrial and Systems Engineering. Dr. Pritchett received bachelor's, master's, and Sc.D. degrees in aeronautics and astronautics from MIT in 1992, 1994, and 1997, respectively. Dr. Pritchett has led numerous research projects sponsored by industry, NASA, and the FAA. She has also served as Director of NASA's Aviation Safety Program, responsible for planning and execution of the program, conducted at 4 NASA research centers and sponsoring roughly 200 research agreements; in that role, she also served on the Office of Science and Technology Policy Aeronautic Science and Technology Subcommittee, and the executive committees of the Commercial Aviation Safety Team (CAST) and the Aviation Safety Information Analysis and Sharing (ASIAS) program. She has published more than 170 scholarly publications in conference proceedings and in scholarly journals such as Human Factors, Journal of Aircraft and Air Traffic Control Quarterly. She has also won the Radio Technical Commission for Aviation's William H. Jackson Award and, as part of Commercial Aviation Safety Team (CAST), the Collier Trophy, and the American Institute of Aeronautics and Aviation has named a scholarship for her. Dr. Pritchett is the Editor in Chief of the Journal of Cognitive Engineering and Decision Making. She is also a licensed pilot. She recently chaired a National Research Council (NRC) study examining air traffic controller staffing.

Professor Rolf Radespiel studied Mechanical Engineering at the Technische Universität Braunschweig in Braunschweig, Germany and was awarded a PhD degree at the same university in 1986. From 1989 till 2000 he served as a branch head at the DLR-Institute of Aerodynamics and Flow Technology in Braunschweig. Since 2000 he is full Professor at the department of Mechanical Engineering of Technische Universität Braunschweig. His honors include: Dr. Ernst Zimmermann Memorial Award (1986), Wilhelm Hoff /Johann Maria Boykow Award (1988), Science and Technology Organization: Scientific Achievement Award (2011), Cross of the Order of Merit of the Federal State of Lower Saxony (2013). His research interests include aerodynamic design of transport, high-speed and hypersonic space vehicles, high lift aerodynamics, flow control, flapping wing propulsion, physical modeling in transition and turbulence for low speed and hypersonic flow problems.

Professor Christoph Reigber studied Geodesy at the Technical University Munich (TUM) and received his PhD (1969) and Habilitation degree (1974) at the same university. After 10 years as lecturer and project manager for a DFG research programme on Satellite Geodesy at TUM, he became in 1980 director of the German Geodetic Research Institute (DGFI) in Munich. In 1982 he was appointed Professor at TUM and from 1992 to 2005 he was director of the department "Geodesy and Remote Sensing" of the German Research Centre for Geosciences GFZ at Potsdam. In 1993 he became full Professor at the department of Geosciences of the University Potsdam. His honours include: honorary doctorate from University Bonn (1998), honorary professorship of Wuhan University (2005), corresponding member of the Bavarian Academy of Sciences (2002), member of Academia Europaea (2014), Alexander von Humboldt Award (1985), Fellow of IAG (1991), AGU Fellow (1994), Vening Meinesz Medal of EGS (2002), DGLR Werner von Braun Medal (2003), NASA Earth Explorers PO GRACE Mission Award (2006), 2007 William T. Pecora Award for GRACE Team, DOI & NASA, Grand Prix 2010 of French Air and Space Academy. His research interests include: determination of global gravity field, Earth kinematics and orbit control of satellites.

Professor Raimund Rolfes graduated in civil engineering at Leibniz Universität Hannover (LUH). He received his Ph.D. in Computational Mechanics from the same University and his habilitation (2nd Ph.D) from Technical University of Dresden. He has worked for 16 years for the German Aerospace Center (DLR) in the field of fiber composite structures, where he ran a department for computational analysis and experimental validation with 40 co-workers. Since 2005 he is head of the Institute for Structural Analysis at LUH. Since 2010 he is also head of the Hannover branch of the Fraunhofer institute for wind energy and energy system technology, since 2013 he is speaker of the board of ForWind. Professor Rolfes is reviewer for research organizations in five countries, for the EU and for more than 20 international journals. He was member of an international peer review group for the department of mechanical engineering of Politecnico di Milano. His working areas are computational dynamics, structural health monitoring, modelling ans simulation of fiber composite structures. He has more than 200 publications, out of which are 55 peer-reviewed journal papers (H-index:20). In 2010 Professor Rolfes received the best paper award of the Int. Journal of Structural Stability and Dynamics. In 2012 he was awarded the Eric-Reissner-Medal of the International Conference on Computational & Experimental Engineering and Sciences, since 2012 he is also member of the "Braunschweigische Wissenschaftliche Gesellschaft".

Professor S. Mark Spearing was appointed Professor of Engineering Materials in the School of Engineering Sciences at Southampton University in July 2004. He has subsequently served as Head of the School of Engineering Sciences and currently as Pro Vice-Chancellor (International). Prior to his appointment at Southampton he was a Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology, from 1994-2004, receiving tenure in 2001 and being promoted to a Full Professorship in 2004. His technical interests include materials, processes and structural design, micro- and nano-systems, structural health monitoring and advanced composites. Spearing is a past chairman of the American Institute of Aeronautics and Astronautics Materials Technical Committee, and is a life member and associate fellow of AIAA and a fellow of the Royal Aeronautical Society. He is a member of ASME. He is an editor of the Journal of Composite Materilas and also of the ASME/IEEE *Journal of Microelectromechanical Systems*. He has published over 170 technical

publications, including more than 100 in refereed journals. He holds 5 patents. While at MIT he received four departmental awards for undergraduate teaching and advising. In 2004 he received a Royal Society-Wolfson Research Merit Award.

APPENDIX B SITE VISIT PROGRAMME

Sunday November 16th 2014

Time	***Activity***	***Participants***
- 15.00	Arrival of committee	Committee (private)
15.30	Introduction committee members	Committee (private)
16.30-19.00	Formal kick-off and preparation of interviews	Committee (private)
19.30	Welcome of committee	Committee + Dean + MT + Rector Magnificus DUT+ President of DUT Board
20.00	Diner	Committee (private)
21.30	Closure	

Monday November 17th 2014

Time	***Activity***	***Participants***
8.30- 9.05	Management interview 1st assessor: Prof. De Boer 2nd assessor: Prof. Graham	Prof.Dr.Ir.Drs. H. (Hester) Bijl, Prof.Dr.Ir. R (Rinze) Benedictus, Prof.Dr. E.K.A. Gill, Prof.Dr.Ir. M. (Max) Mulder, prof.dr. F. (Fulvio) Scarano
9.20- 9.55	Interview Research Group Structural Integrity & Composites 1st assessor: Prof. Spearing 2nd assessor: Prof. Graham	Prof.Dr.Ir. R.(Rinze) Benedictus, Dr.Ir. R.C. (Rene) Alderliesten, Dr. S.(Sofia) Teixeira de Freitas
10.10- 10.45	Interview Research Group Aerospace Structures & Computational Mechanics 1st assessor: Prof. Rolfes 2nd assessor: Prof. Radespiel	Dr. C. (Christos) Kassapoglou, Dr. M. (Mostafa) Abdalla, Ir. S. (Sonell) Shroff
11.00- 11.35	Interview Rector Magnificus DUT + dean 1st assessor: Prof. De Boer 2nd assessor: Prof. Radespiel	Prof.Ir. K.C.A.M. (Karel) Luyben, Prof.Dr.Ir.Drs. H. (Hester) Bijl
11.55- 12.30	Interview Research Group Novel Aerospace Materials 1st assessor: Prof. Spearing 2nd assessor: Prof. Rolfes	Prof.Dr.Ir. S. (Sybrand) van der Zwaag, Dr. S.J. (Santiago) Garcia Espallarges, Ir. H. (Hamideh) Khanbareh
12.45	Lunch	Committee + 11 Tenure Trackers M. Kotsonis, A.Sciacchitano, D. Ragni,A. Vire, S. Hartjes, W. Verhagen, B. Lopes dos Santos, C. de Visser, E. van Kampen, W. van der Wal. S. de Freitas
13.45	Lab tour, Round tour facilities	Cleanroom, Windtunnel, Simona, Flight Hangar

14.45-15.20	Interview research Group Air Transport and Operations 1st assessor: Prof. Pritchett 2nd assessor: Prof. Spearing	Prof.Dr. R. (Richard) Curran, Prof.Dr.Ir. H.A.P. (Henk) Blom, S. (Sander) Hartjes
15.35-16.10	Interview Research Group Aircraft Noise and Climate Effects 1st assessor: Prof. Graham 2nd assessor: Prof. Pritchett	Prof.Dr. D.G. (Dick) Simons, Dr.Ir. M. (Mirjam) Snellen
16.25-17.00	Interview Research Group Control and Simulation 1st assessor: Prof. Pritchett 2nd assessor: Prof. Reigber	Prof.Dr.Ir. M (Max) Mulder, Dr. Q.P. (Ping) Chu, Dr. G.C.H.E. (Guido) De Croon
17.30	Refreshing at hotel	Committee (private)
18.30	Diner	Committee (private)
20.30	Discussing and writing preliminary judgments	Committee (private)
21.30	Closure	

Tuesday November 18th 2014

Time	***Activity***	***Participants***
9.00-9.35	Interview Graduate School: Director of Graduate School + PhD mentor 1st assessor: Prof. De Boer 2nd assessor: Prof. Spearing	Prof.Dr.D.G. (Dick)Simons, Prof.Dr.Ir. G.A.M. (Gijs)van Kuik
9.50-10.25	Interview Research Group Flight Performance & Propulsion 1st assessor: Prof. Radespiel 2nd assessor: Prof. Pritchett	Prof. Dr.Ir. L.L.M. (Leo) Veldhuis, Prof.Dr.Ir. P (Piero) Colonna, Dr.Ir. M. (Marc) Voskuijl
10.40-11.15	Interview Research Group Aerodynamics 1st assessor: Prof. Radespiel 2nd assessor: Prof. Graham	Prof.Dr. F. (Fulvio) Scarano, Dr. R.P. (Richard) Dwight, Dr.Ir. B.W. (Bas) van Oudheusden
11.30-12.05	Interview Research Group Wind Energy 1st assessor: Prof. Graham 2nd assessor: Prof. Rolfes	Prof.Dr. G. J.W. (Gerard) van Bussel, Dr. Ir. M.B. (Michiel) Zaaijer, Dr.Ir. C.J. (Carlos) Simao Ferreira
12.30	Lunch tenured-staff	René van Paassen (C&O) Arvind Gao (AWEP) Daphne Stam (SpE) Irene Fernandez Villegas (ASM)
13.30-14.05	Interview non-tenured staff 1st assessor: Prof. De Boer 2nd assessor: Dr. Pritchett	Andries Koopmans Mauro Gallo Prem Sundaramoorthy Ranjita Bose

14.20-14.55	Interview PhD's	Emmanuel Sunil, Ricardo Perreira, Steven Engelen, Noud Werter
15.10-15.45	Interview Advisory Council 1st assessor: Prof. De Boer 2nd assessor: Dr. Reigber	J. Rotteveel – Isis R. van Maanen – EU W. Pasteuning - Fokker
16.00-17.00	Discussing and writing preliminary judgments	Committee (private)
17.00	Refreshing at hotel	Committee (private)
18.00	Diner	Committee (private)
20.00	Discussing and writing preliminary judgments	Committee (private)
21.00	Closure	

Wednesday November 19th 2014

Time	***Activity***	***Participants***
9.00-9.35	Interview Research Group Astrodynamics and Space Missions 1st assessor: Prof. Reigber 2nd assessor: Prof. Radespiel	Prof.Dr.Ir. P.N.A.M. (Pieter) Visser, Prof.Dr. L.L.A. (Bert) Vermeersen, Dr.Ir. E.N. (Eelco) Doornbos
9.50-10.25	Interview Research Group Space Systems Engineering 1st assessor: Prof. Reigber 2nd assessor: Prof. Spearing	Prof.Dr. E.K.A.(Eberhard) Gill, Dr. J. (Jian) Guo, Dr.Ir. C.J.M.(Chris) Verhoeven
10.40-11.15	Summarizing findings and first conclusions	Committee (private)
11.15-11.50	Concluding meeting with management	Committee + Dean + MT
11.50-12.30	discussing and writing preliminary judgments	Committee (private)
12.30-13.00	Oral presentation on first impression by committee	Committee, Dean, MT and (assistant & associate) professors and other interviewed personnel
13.00	Closure	*Drinks with Committee and Faculty*

Between each interview, time is reserved for a *wrap up* by the Committee. To improve the readability this activity is omitted from the table.

APPENDIX C EXPLANATION OF THE SEP SCORES

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

Quality is seen as the contribution that research makes to the body of scientific knowledge. The scale of the unit's research results (scientific publications, instruments and infrastructure developed by the unit, and other contributions to science) are also assessed.

Relevance to society is seen as the quality, scale and relevance of contributions targeting specific economic, social or cultural target groups, of advisory reports for policy, of contributions to public debates, and so on. The point is to assess contributions in areas that the research unit has itself designated as target areas.

Viability is seen as 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. It also considers the governance and leadership skills of the research unit's management.

The categories in this SEP and the descriptions differ from the scores in prior SEPs and are therefore not comparable.

Quicken ORGANISATIE ADVISEURS

bureau voor organisatieontwikkeling