

Ten Year Review of the Aeronautics and Astronautics Department

I. COMMITTEE:

Per G. Reinhall, Professor and Chair, UW Mechanical Engineering (Committee Chair)

Robert Holzworth, Professor, UW Earth & Space Sciences

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II. SUMMARY OF THE REVIEW PROCESS

The review committee received an extensive Self Study document prepared by the Aeronautics and Astronautics (A&A) Department. The committee also received the previous review of the department conducted February, 2001. The review committee conducted a site visit January 30 and 31. The committee met with Jim Hermanson, Chair of the A&A Department, members the A&A faculty and staff, and students from the undergraduate and graduate student population. In addition the committee conducted a conference call with graduate students enrolled in the department's on-line masters program. The committee also toured the renovated Guggenheim Hall, including classrooms and laboratories. The agenda of the site visit is attached to this report.

Response: The A&A Department would like to thank the Review Committee for its efforts in performing this review, including the site visit and the thoughtful comments in this review report. We are happy to respond to these comments in the discussion below (each such response is indented and identified).

III. FINDINGS

Strengths

Undergraduate Program

The Department has strong programs in both aeronautics and astronautics. Notable strong points in the undergraduate curriculum include world-class senior capstone classes in both aeronautics and astronautics. These capstone classes not only teach engineering fundamentals but also teach organizational skills and project management skills. It is notable that the aeronautics capstone class routinely is successful in the design/build/fly aspect of their project every year. Another strong point of the department is the associated undergraduate laboratories. The ~~Kristen~~ Kirsten Wind Tunnel is a large scale facility which is also used by industry and gives the students real-world experience that is immediately useful in the aerospace industry. The ~~Ferrari~~ Lamborghini Advanced Composites Structures Lab provides hands-on experience with composite structures, which is at the forefront of aerospace design and application.

The committee noted strong young faculty in both fluids and controls, fundamental areas for aerospace engineering. The controls area has attracted some research contract work, which provides opportunities for undergraduate student research.

The undergraduate program in A&A focuses on both aeronautics, with emphasis on vehicles that operate in fluids, and astronautics, with emphasis on vehicles which leave the Earth's atmosphere and operate primarily in space. The undergraduate student body is nearly equally

split between these two branches of engineering. The A&A Department has faculty with interests in each area, also nearly equally split. While the needs of the student body are met by the dual emphasis, there is concern that for a small department there may not be sufficient resources to do both of these focus areas well enough to be considered in the top echelon of A&A departments. This dual focus issue is exacerbated by the fact that nearly a third of the faculty are focused on plasma physics, a related area but not necessarily integrated with the undergraduate curriculum in either aeronautics or astronautics.

Response: The research activities and interests of the A&A faculty are not equally split between aeronautics and astronautics, but are more focused on aeronautics. Of the current fifteen FTE A&A faculty, roughly eight have research interests primarily related to aeronautics, four are more astronautics-focused, and three others could be characterized as having a mix of research interests. The three faculty focused on plasma research represent one-fifth of the current tenure-track faculty.

The education needs of the State of Washington include the training of engineers in both aeronautics and astronautics. All of our faculty (whether their research interests lie in aeronautics, astronautics, or plasmas) are involved with undergraduate teaching. The effectiveness of the faculty in providing a top-quality educational program is not hindered by the fact that undergraduate course topics do not necessarily have close parallels to funded research topics, as is true in all academic fields.

The integration of the plasma group with the aerospace focus of the department is continuing to increase. The last faculty member hired in the plasma area has specific interests in space propulsion that strengthen the existing connection between plasma physics and astronautics. Other plasma faculty are aiming to develop new research programs related to aeronautics and astronautics. Regarding undergraduate education, specific, relevant plasma-related components include the courses AA405 (Introduction to Aerospace Plasmas) and the addition of significant electric space propulsion elements into AA360 (Propulsion). There is also significant undergraduate involvement in plasma research and independent study courses. Finally, it is worth noting that the enrollment of plasma graduate students in the department has nearly doubled in ten years, from 14 in A-01 to 27 in A-11.

Students that the committee interviewed expressed satisfaction with the program. They found the program to be challenging and of very high quality. The students were pleased with the faculty and their dedication to teaching. It was reported that the professors showed a genuine interest in student learning and that they were available for extra help when necessary. It was felt that the student body develops into a cohesive community in the junior year which promotes a strong desire to work together in groups. The atmosphere in the department is very much appreciated by the undergraduate students. All the students we talked to were happy with their choice of engineering discipline and department. Some students thought that the program was over-emphasizing the aeronautics focus of the A&A discipline at the expense of the astronautics part. Student suggestions for future improvements were to increase the astronautics-related course offerings, and that the courses in the field of structures could be made more A&A specific. The committee notes that the national direction in astronautics is unclear, with the manned-space program having little direction and the mission for NASA unclear. The committee recommends that the A&A Department leadership needs to track and understand national priorities in future strategic planning.

Response: We appreciate the positive student feedback regarding our educational program and their satisfaction with the department. While we recognize that our current curriculum does reflect a somewhat proportionally greater emphasis on aeronautics than on astronautics, we feel that this is not inappropriate given the much larger amount of aeronautics-based activity nationwide (both in terms of industrial production and funding for research and development), and the corresponding greater number of jobs compared to the space field. We appreciate the need to better inform students of the reasons for the relative emphases on the two areas. At the same time, we are considering how to increase the astronautics-related content of our curriculum.

We agree with the Review Committee that understanding evolving national priorities in space is important to the future of our department. The department's Strategic Planning Committee shall be engaged to address this point.

Certificate Program in Aircraft Composite Structural Analysis and Design

The committee was impressed with the impact of the Advanced Composite Structure Certificate Program jointly offered with the MSE and ME departments. To date approximately 275 Boeing employees have completed the program and it is clear that the program serves industry well with distance learning opportunities for their employees. The committee recommends a stronger link to this certificate program with the A&A department, which will also facilitate stronger links to local industry.

Response: We are very pleased with this certificate program. This particular program is specific to Boeing employees only, as it covers material that is Boeing-proprietary. We are currently considering initiating a new, parallel certificate program that would be open to anyone. Ties with industry will also be strengthened by the introduction of the Professional Masters' Program (PMP) that we are current developing. Both the PMP and the certificate programs will be addressed by the department's Strategic Planning and Visiting Committees.

Plasma Group

The plasma group has a stellar record and continues to be very productive both when it comes to funding and scholarly output. We found the faculty in the group to be very energetic and involved with interdisciplinary work at the forefront of plasma science and engineering. However the relevance of the Plasma Group to the mission of the A&A Department is unclear. As the committee understands the history, the Plasma Group was merged into A&A when the UW Nuclear Engineering Department was disbanded. The scientific tie to A&A is through fluid mechanics, of course. While the Plasma Group attracts the vast majority of externally funded research grants to the department, the committee is concerned that this small engineering department essentially has three diverse fields to integrate: aeronautics, astronautics, and plasma physics.

Response: We appreciate the recognition of the many strengths of our outstanding program in plasma science. As stated above, there is already direct relevance of the research within that area to space propulsion, as well as the connections to fluid mechanics pointed out by the Review Committee. Plasma Group faculty are also well-integrated with the educational mission of the department. It should also be pointed out that there is typically a breadth of research within any engineering department. As such, all faculty research is not necessarily tightly integrated with other discipline groups within a department, with other faculty within

the group, or with the name of the department. A few current examples in Aeronautics & Astronautics include research on asteroid collisions, grocery store coolers, automobile composites, fusion energy, and applications of controls theory to cancer research). All of these projects represent desirable interdisciplinary work. Our Strategic Planning Committee, in conjunction with the Visiting Committee, will continue to explore ways to further strengthen the integration of our plasma-related activities with those of the rest of the department.

Although the A&A Department is not large, we feel that the educational goals of our students, as well as the research needs in aerospace and energetics, require us to continue our activities in aeronautics, astronautics, and plasmas.

Center for Advanced Materials in Transport Aircraft Structures (AMTAS)

The FAA sponsored AMTAS, managed out of the ME Department, is clearly an asset to University of Washington. Since future aerospace vehicle designs will require a plethora of advances in lightweight composites structure engineering and manufacturing, an expansion of AMTAS through an increased involvement by the A&A Department would seem to create significant opportunities for the near future. This center has also the potential of strengthening the connection between the A&A Department and Boeing.

Response: We agree that AMTAS has a role to play in strengthening the connection between A&A and Boeing, and that this center, and research in composite materials and structures in general, needs to be a major focus in developing and expanding collaborations between A&A and Boeing. Strengthening the connection between A&A and Boeing is a stated goal as part of our Strategic Plan.

Junior Faculty

The department has been able to hire five faculty members within the last 10 years. The committee met Assistant Professors Ferrante and You and Associate Professors Dabiri and Morgansen. The committee was impressed with the quality and enthusiasm of the junior faculty as a whole. The junior faculty has invigorated the controls focus of the Department and brought in research in that area. They are considering developing a Center of Excellence for controls. One potential improvement identified by the junior faculty members is to introduce procedures to enable adoption of new strategies and initiatives.

Response: Our Strategic Planning Committee has in the past year been re-constituted to specifically include all of the junior faculty in the department, giving them a direct voice into the planning of new initiatives for A&A. The Strategic Planning Committee meets quarterly.

It should be noted that during the last ten years the department actually hired *eight* new faculty members (five in 2001-2002, one in 2005, and two in 2008). Of these new faculty, one has since left the University.

On-line Masters Program -- EDGE

The Committee got an opportunity to discuss the department's on-line masters program with six registered students. The overall opinion of the students is that the on-line masters program through EDGE works very well. Some areas for improvement include better access to faculty,

especially getting help through e-mail; and improved course offerings. Apparently, lack of enrollment in specific courses had led to limited distance-learning course offerings.

Response: The introduction of the PMP will address some of the concerns about course offerings, in that that program will have fewer courses but they will be offered on a more consistent basis than the existing MSAA program. Access to faculty for help with coursework for online students remains an issue, in part, due to the difficulties inherent in communicating complicated technical concepts via email and phone conversations, as opposed to face-to-face encounters. We are considering ways in which the online-help experience might be enhanced, such as by having faculty and TAs reschedule some office hours to better correspond to EDGE students' after-work hours, as well as increasing the use of e-tools such as online blackboards.

Graduate Advising

The graduate students praised the graduate advisory staff during our meeting. They all found the availability and the quality of the advising office to be excellent.

Opportunities

Strategic partnership with industry

The location of Boeing and many of its suppliers in the Pacific Northwest make Seattle a world center for aerospace engineering and manufacturing. The A&A Department therefore has a wonderful opportunity to establish close strategic partnerships with key companies within the aerospace industry. These partnerships could result in an increase in research funding and better research opportunities, higher impact on industry, better opportunities for undergraduate and graduate students, and an increase in endowments.

Response: We agree absolutely with the above statements. Strengthening our industrial collaborations and partnerships is a major element of our current Strategic Plan. As part of this, in the past year we have formed two faculty working groups, one focused primarily on aeronautics, with Boeing as the leading, target partner institution, the other on astronautics, involving Aerojet and other space-related companies in the Puget Sound area. We will also explore ways in which to grow these important partnerships with our Visiting Committee.

Grow composite work to support industry's long-term goals, including nano-technology. The next generation of composite aircraft presents a host of engineering problems to be overcome in areas such as design architecture and optimization, aeroelasticity, damage tolerance, material properties optimization, electromagnetic properties, surface finish, and acoustics and vibrations. The department therefore has an opportunity to implement fundamental composite research that may support the long-term goals of industry and attract research funding. The department can also play an important role in the Northwest region in educating future composites engineers, which will be in tremendous demand by local and national employers.

Response: The area of composite aircraft structures is clearly important to the future of aerospace engineering. As a result, we plan on continuing to strengthen our research and education activities in this area, including the development of the PMP mentioned above. In addition, we expect to be doing additional faculty hiring in the area of aerospace structures.

Industrial Advisory Board

The department needs to revitalize its industrial advisory board to improve its strategic plan and a means of implementing it. The department now has an opportunity to reconstitute its advisory board with new members from local and national aerospace industries. It is the opinion of the committee that the members of the board should be from industry and that there is little need to select members from academia as has been done in the past. At the minimum the board should meet twice a year to advise the department about issues such as current needs and trends in research, development and implementation of a strategic plan, funding and entrepreneurial opportunities, capstone design, curriculum needs, on-line programs, and how industry and the department can serve each other better.

Response: We are planning on re-forming our Visiting Committee this year, and on holding a meeting with them and the department this fall. We agree that this is an opportune time to do so, and that we need to ensure a strong industrial presence on that committee. At the same time, we think that it is also important to include academic members on the Committee, who understand the conditions at universities and the accompanying challenges. Beyond this, we would argue that while academic research should be informed by industrial needs, it cannot be completely determined by them. We believe that an annual on-campus visit of the full Visiting Committee, combined with less formal updates throughout the year (including electronic updates and visits from local Committee members), would be the optimum use of our Visiting Committee.

Leverage growing entrepreneurial opportunities in civilian space development

There is an ongoing paradigm shift in space exploration. The shift is away from NASA centered programs towards smaller programs managed by private companies. The committee believes that there might be opportunities associated with this shift that the department can exploit to its advantage. For example, there are many groups and commercial organizations who are actively building small or miniaturized satellite (cubesat, nanosat and smaller) programs. A large number of commercial companies are now getting into the business of building the commercial launch vehicles as well as developing systems engineering parts for these novel types of satellite systems. NASA's Office of the Chief Technologist is actively promoting this activity. It is the opinion of the committee that this national shift to smaller satellites and commercialization of launch vehicle systems may present an opportunity for the department to increase its focus on astronautics in both teaching and research.

Response: We agree with these remarks and are using our Astronautics Working Group precisely to respond to these, and other, space-related challenges. In addition to working with Aerojet, the working group is exploring ways to strengthen partnerships with other space companies, including Blue Origin, SpaceX, and others.

Fill the Boeing Endowed Professorship

The Boeing Endowed Professorship has been unassigned since 2005 and has accumulated a significant amount of unused funds. The Department should make it a priority to fill this position to strengthen the faculty, be prepared for near-term retirements, and to satisfy its commitment to Boeing. The on-going search for a new faculty member in the controls area may provide a good opportunity to fill this endowed professorship.

Response: Assigning the Boeing Professorship to our new faculty hire in the area of controls is precisely our current plan.

Appoint active affiliate professors from industry

An effective way to improve connections with industry is to appoint strategically selected technical experts as affiliate professors. For example, there might be several nationally recognized researchers at the Senior Fellow level at Boeing who would be willing to initiate collaborative research programs and to teach and develop graduate courses and to advise graduate students.

Response: We agree, and this item is already part of our Strategic Plan. Furthermore, we already have a number of affiliate faculty who teach undergraduate courses or are engaged in other activities in the department.

Improve communication within the department by forming a staff advisory committee.

The staff as a group (or as sub-groups) does not have regular meetings with the Chair of the department. As a result there seems to be some lack of coordination between the staff and the faculty. The committee believes that there exists an opportunity to improve the working relationships within the department if staff committees were set up to meet regularly with the Chair to discuss issues regarding advising, academics, and infrastructure.

Response: The comment from the staff about regular meetings with the Chair is incorrect. The Chair meets with all staff quarterly, by functional group (computing, fiscal, etc.) to discuss issues pertaining to their job functions. In addition, quarterly information/discussion sessions between the Chair and the combined staff are currently being conducted. A staff committee has been organized to coordinate department events involving the staff and faculty/students, and has proved successful over the past year.

Creation of an advisory role for the students

The department lacks any formal student involvement in its committee structure. There are no students on any of the standing committees and the Chair is currently not meeting regularly with student's representatives. We believe that this lack of student participation is a missed opportunity and should be corrected.

Response: We have already formed a committee of undergraduate students who are providing feedback on the undergraduate program to the Undergraduate Faculty Advisor (and, eventually, to the Chair). We shall form a similar committee consisting of graduate students. Beyond this, we are considering including students on appropriate, standing A&A Department committees, as many departments already do.

Leadership in pursuing large multidisciplinary grants

To increase the department's national stature and to strengthen its PhD program, the department would be well advised to increase its activity level and leadership role in the pursuit of large multidisciplinary grants such as MURIs, GAANNs and IGERTs (the department is currently involved in one MURI (Morgansen)).

Response: We agree with this goal; this item is specifically identified in our Strategic Plan. In addition, attracting a new faculty member with leadership potential in large,

multidisciplinary grants is one priority in our current faculty hiring process. The department is currently involved in three MURI's, in both PI and co-PI roles.

Weaknesses

The department does not have adequate industry connections

This weakness needs to be addressed in the department's strategic plan. We are especially troubled by the fact that the department is not particularly well connected with Boeing and its research needs. Researchers at Boeing have much stronger relationships with A&A departments at universities that are located at a great distance away from the Pacific Northwest. The department needs to make it a priority to reach out to Boeing and to show a willingness to conduct research that is relevant to the aircraft industry. It should be noted, however, that industry connections are not solely formed by reaching out to industry but that it also requires faculty to be leaders in research areas that are in demand by industry. We believe that this needs to be considered in the selection of new faculty. It is recommended that improving industry relationships needs to be a long-term commitment of the Department. It will take some time and patience for these relationships to form, for industry-relevant research to be established, and for industry to become more interested in partnering with the UW A&A Department in research projects of significance.

Response: We agree completely that the connections between A&A and local, and national, aerospace industry can be, and ought to be, significantly strengthened and expanded. We will continue to reach out to industry, through individual faculty, the Department Chair, and our Aeronautics & Astronautics working groups. Initiating a local research symposium for our graduate students, to which industry will be specifically invited, is part of our current Strategic Plan. We expect that our Visiting Committee will also be able to help with this important effort. The new PMP will also serve to help strengthen our industrial connections. We fully understand and appreciate the time and patience required for these efforts, and affirm that this is a priority area for the department going forward. We are also continuing to pursue the possibility of securing a major, department-naming-level gift through an industrial sponsor. One challenge involving working with industry is that industrial research tends to focus more on short-term problems and applications that are more suitable for MSA students than for PhD dissertation research, which is normally more fundamental and longer-term in duration.

The external advisory board is not effectively used

The department has an external advisory board with members from industry and academia. However, this board is not being effectively used in that it has not been meeting regularly. A functional and active industrial advisory board is a crucial asset to the department in the development and implementation of a strategic plan.

Response: We agree and, as stated above, we will be re-activating and re-constituting our Visiting Committee this year.

The Plasma Group is responsible for the majority of the research expenditure

The research expenditures of the controls, fluids, and structures groups need to be increased. The junior faculty members in these groups are active but the average research productivity of the groups is too low.

Response: We agree that increasing the level of research activities in the department is important. This is particularly true in the areas of fluids and structures, recognizing the current funding challenges in these areas. Strategies for doing so are identified in our current Strategic Plan.

Risk

Age structure

The department has excellent senior faculty in a wide range of areas. However, several faculty members are close to retirement and the average age in the department is high. The challenge in the view of this departmental age structure will be to define areas for hire that will allow the department to fill teaching needs and build strength in new directions that link across departmental boundaries. We therefore urge the department to place these future hires in the context of a well thought out strategic plan.

Response: We appreciate the challenges stated here, and agree that the hiring of new faculty into the department represents a challenge, but also a major opportunity for growth, in the coming years. One major challenge will be procuring the necessary start-up funding to support these new faculty hires. The PMP mentioned above will help to generate sufficient funds to support these critical hiring needs. We will also consider how to ensure that, within the framework of our current Strategic Plan (developed in 2009); we continue to define areas for new hiring that strengthen the department internally as well as in increasing collaborations across departments, colleges, and universities. Our current hiring effort in the area of controls is being done specifically with such cross-boundary collaborations in mind.

No systems engineering

The department does not offer any undergraduate or graduate courses in systems engineering. Being multi-disciplinary in nature, aerospace engineering is an ideal environment for systems engineering concepts. Coupled with improved local industry relationships, a systems engineering curricula could present a growth area for the Department in place of mature traditional aerospace focus areas. Our recommendation is that there should be some attention given to a possible expansion of the curriculum to include system engineering courses.

Response: The A&A Department has been offering a course in Systems Engineering, AA 470, since 2007. This four-credit course is offered every autumn quarter, jointly with the UW Industrial and Systems Engineering Department, and the course had 47 students enrolled in 2011. The course is offered both on-campus and on EDGE, making it readily available to both undergraduate and graduate students (there were 27 EDGE students in AA470 in 2011). The department has access to excellent outside instructors available to continue to teach this course.

Low graduated PhD/faculty

The department has had a graduation rate of approximately 4PhDs/year the last 10 years. This equates to about 0.27 PhD/year per faculty. This is low compared to peer institutions (Purdue, Michigan, Texas A&M, Maryland, etc). The department would be well advised to increase the PhD graduation rate to achieve its goals as stated in department's strategic plan of increasing its national and international recognition and significantly increase national and international recognition.

Response: We agree that increasing the number of PhD graduates in the A&A Department is an important and worthwhile goal. The number of PhD students in the department has increased in 2011-2012 by 29% from the four-year average. We expect this number to further increase with the hiring of new, dynamic faculty into the department.

IV. RECOMMENDATIONS

The unanimous opinion of the members of the review committee is that:

1. The Aeronautics and Astronautics Department BS, MAE, MSAE, and PhD Programs should be renewed for 10 years with no need to file an interim report

Response: We appreciate this recommendation and thank the members of the Review Committee for all of their efforts, and constructive feedback, during this process.

2. The department should reinvigorate its industrial advisory board. This board can advise the department about issues such as current needs and trends in aeronautics and astronautics research, development and implementation of a strategic plan; funding and entrepreneurial opportunities, capstone design, curriculum needs, on-line programs, and opportunities for joint Department/industry interactions. The department needs to make active use of the board with a minimum of two meetings per year.

Response: We agree and are planning to re-activate the A&A Department Visiting Committee, as stated above.

3. The department needs to develop a comprehensive 10-year strategic plan that involves the development of strategic partnerships with the aeronautics and astronautics industry and then set up a system to implement the plan. This should be done in close working relationship with the industrial advisory board.

Response: As mentioned above, the A&A Department does have a recent Strategic Plan, completed in 2009, and included in the Unit Self-study Report as Appendix K. The Plan can also be accessed here (<http://www.aa.washington.edu/about/stratplan.html>). Our Strategic Planning Committee, as mentioned above, is responsible for overseeing the ongoing implementation of the Plan and assessment of outcomes. The Committee will revisit the Strategic Plan and ensure that it addresses the suggestions raised during this review process.

4. The department should track and understand national priorities in astronautics in future strategic planning. The national shift to smaller satellites and commercialization of launch vehicle systems may present an opportunity for the department to increase its focus on astronautics in both teaching and research.

Response: We agree with this suggestion and, as stated previously, the department's Strategic Planning Committee will be engaged to address this point.

5. Hiring of new faculty must be a high priority in order to enable the department to improve its nationally ranked graduate and research program. We recommend that the hiring be done in the

context of a well thought out strategic plan. It is recommended that the Boeing Endowed Professorship be filled as soon as possible.

Response: We are in the process of hiring a new faculty member in the general area of controls this quarter. The plan is to use the Boeing Professorship as part of this hiring. The Professorship is normally assigned on a three-year term, and will therefore be an available resource for future hiring as well. Upcoming retirements are likely to result in additional opportunities for the hiring of new faculty. We are also working with the College of Engineering's Advancement Office to help raise the needed funds for these new faculty hires (one particular challenge is providing substantial, competitive start-up packages). The PMP program we are developing is expected to generate additional revenue that will also be helpful in hiring new faculty.

6. The hiring of lecturers should be a priority. The hiring of lecturers would allow an increase in enrollment without increasing the faculty teaching load. The additional use of lecturers would also improve the opportunities environment for faculty to pursue additional research.

Response: This is a good idea. We are currently developing a proposal for a Professional Master's Program, that will be well-served by such additional lecturers, as well as providing the additional income needed to support them.

7. Appointment of active Affiliate Professors to enhance research cooperation with industry. We believe that the Boeing Senior Fellows are valuable local resources who should be considered for appointment.

Response: We agree with this suggestion, and this item is included in the current Strategic Plan. Although we currently have a number of affiliate faculty in the department, increasing the use of senior Boeing engineers in this regard is an identified priority in the Plan.

8. The department needs to pursue a vigorous program to increase the research expenditures of the controls, fluids, and structures groups. Success of both large team grants and individual investigator grants will naturally lead to an increase in graduate student productivity

Response: We agree with this priority and have identified means for approaching this issue in our Strategic Plan.