10-Year Review of Aeronautics and Astronautics

The full review committee met February 5 and 6 with Adam Bruckner, Chair Aeronautics and Astronautics, members of the A & A faculty, A &A staff and student groups representing undergraduates, MSAA students and PhD candidates. In addition, the internal members of the committee met with Adam Bruckner January 16 and with faculty, staff and students January 25, 26, 30 and 31. The schedule of meetings and a list of those in attendance are included with this report as ADDENDUM 1.

Our assessment of the condition of the Department is in distinct contrast to that expressed by the review committee that reported in 1991. There is an optimistic view of the future among nearly all faculty and staff. The primary basis for this is the knowledge that a substantial number of relatively inactive faculty have retired or will be retiring in the near future and the expectation that the pool of promising new faculty is sufficient to ensure new hires as active and productive as those that have joined the Department in the immediate past. Thus the Department has a major new resource in the form of faculty vacancies that did not exist ten years ago. There are other factors contributing to the optimism that are almost as important. The Department has developed a strategic plan that gives a sense of direction to future personnel and programmatic changes. They have also considered what support staff is necessary and the staff reorganization plan has, with one notable exception, been fully implemented. In contrast to the declining student enrollments in 1991, enrollments have been increasing substantially, especially at the undergraduate level. Finally, it would be hard to overestimate the effectiveness with which Adam Bruckner has directed the planning and reorganization efforts and has inspired confidence among all that these efforts will succeed

In the document that follows, we will attempt to assess the likelihood that the productivity and quality of the Department will improve as the strategic plan is implemented. A number of reservations will be expressed, but the unanimous view of the committee is that, given adequate University support, very positive changes should occur in the Department. Therefore, our first recommendation is:

1. **The Department of Aeronautics and Astronautics BS, MAE, MSAA and PhD programs should be continued.**

Of the programs in Aeronautics and Astronautics the newest and the least well populated is the MAE program. The reasons for the small number of enrollments are not apparent, but it is clear that some effort must be made to increase enrollment to the point where the effort expended on the program can be justified.

2. **An interim report to the Graduate School and the University should not be necessary.**

Although the degree of success of the Department's plans is likely to be apparent within five years, we do not feel it would be useful to initiate a full review in fewer than ten years. An internal assessment carried out by the Department and reported to the Dean of Engineering might be helpful, however. This could point out where Department planning and needs have changed in response to opportunities unseen at this time and, most importantly, how successful new faculty hires have been.

<u>New Faculty Hires</u>

In the self-study document (p 16) the claim is made that external funding "...is expected to approximately double within five to seven years, as senior faculty retire and are replaced by more active new faculty." It is worthwhile examining this statement in more detail and, in so doing, point out the unusual (for an A&A department) and

uneven funding that exists currently. We will use the research expenditures for fiscal 2000, which are included as ADDENDUM 2, as a representation of research support within the Department. We expect this is not too distorted by short-term fluctuations. In agreement with the self-study, the total direct and indirect expenditures are $3.9M. The striking feature is that fully 75% of these expenditures were by the faculty in the plasmas area. Most of this work is fusion-related, although a small amount is related to space propulsion. Assume, for the sake of argument, that the level of support for plasmas continues unchanged, consistent with the fact that no new hires are planned in this area. In order to double research support over the next five to seven years through new hires (the number will surely not exceed eight), each new hire must bring in support averaging almost $500,000 per year (this estimate assumes, conservatively, that retiring faculty have no research support). This is an unreasonably high figure and should be replaced by a more realistic one. Two of the recently hired junior faculty, Uri Shumlak and Mark Campbell, posted FY2000 expenditures of about $394,000 and $333,000, respectively. Most likely, this represents some upper limit for junior faculty if not senior faculty. No senior faculty member outside the plasma field was responsible for expenditures in excess of $200,000.

The purpose of the proceeding exercise is not to point out that the estimate of the increase in research dollars is inflated, but is intended to underscore the difficulty of meeting the stated goal of doubling research funding by hiring new faculty. Even if a few such persons are found it may prove difficult to retain them. The loss of Mark Campbell is a regrettable example. His hire may have raised expectations about what could be accomplished with junior faculty, but to expect that new junior faculty hires will, on average, match his performance is to expect too much. The performance of senior faculty with established records is much more predictable. Given the lack of leadership from current mid-career faculty, it is imperative that one or more senior hires be made in carefully selected areas. This leads to our recommendation that:

3. **A strong effort should be made to hire one or more senior faculty in areas key to future A&A programs.**

If future faculty hiring is to be successful, the Department must receive much stronger College and University support than it has received in the past. To attract senior faculty with established research programs requires a large investment in equipment and in space. Recent College experience in other areas should be a good guide as to what amounts are required, but less than $500,000 in startup funds and lab space less than 2000 sq ft seem unlikely to attract senior faculty bringing in $500,000 per year. The Department is advised not to attempt to negotiate a commitment of funds of this amount in advance of seeking candidates, but to identify the candidates first and let their quality convince the College and the University that they are worth the investment.

By necessity, most new hires will be at the junior level. If these individuals are to meet the high expectations of the Department, they must be among the best available candidates and they will likely have multiple offers. UW enjoys some competitive advantages such as the Mt. Rainier factor and the presence of Boeing nearby (This second "advantage" may be more hypothetical than real, especially now that corporate headquarters is leaving Seattle). It also has some important disadvantages such as the high cost of living in the Seattle area and the relatively low national ranking of A&A. Thus it becomes particularly important for a new recruit to recognize that this is the place that offers the best opportunities for establishing a successful career. The most helpful element in making the case for the UW is a good startup package. This varies depending on the nature of the research, but an average of $300,000 for equipment and

1000 sq. ft. for space is typical. Without support at this level, A&A will not succeed in capitalizing on the unique opportunity afforded by the faculty vacancies coming in the next few years.

4. **The Department, the College of Engineering and the University should jointly seek to provide competitive startup packages for new faculty.**

A corollary point is that the Boeing endowment would be better used as part of an offer to a good candidate than as a way of raising startup funding.

5. **The Boeing endowment should be used as part of a startup package for a faculty candidate.**

Research Directions

A key organizational approach to future Departmental research activities is stated to be a "systems-based department structure along the broad lines of aeronautical systems, space systems and energy systems." At the moment this is more a statement of intentions than it is of realities. Research activities are organized into the general areas of Controls:Aircraft and Space Systems, Fluids/Propulsion, Fusion/Plasma Science and Solid Mechanics and Structures/Aeroelasticity. The impetus for a systems emphasis - the three systems described are aircraft systems, space systems and energy systems - would appear to be advice from the Visiting Committee and the adoption of a similar systems approach by leading A&A departments such as MIT. The committee is concerned that a desire to include systems elements such as space communications and avionics would spread Department efforts too thin. It is one thing for a department such as MIT, with 40 or so tenured and tenure-track faculty and a like number of research faculty, to cover all aspects of systems and quite another for a department of 16.

It was expressed to the committee that individual investigator funding was declining and that projects employing several faculty were becoming more common. In the absence of specific examples, the committee remains skeptical of this claim. If true, such joint projects will require a greater degree of co-operation than has existed heretofore and a dedicated individual or individuals to make them happen.

6. **The Department should concentrate its research activities on a limited number of carefully chosen areas.**

These areas must include plasmas or otherwise the research activities will be unable to justify the required research infrastructure.

It is unrealistic to expect the Redmond Plasma Physics Lab to be involved to a greater degree with campus activities than it already is. The director teaches two A&A courses per year and a regular plasma seminar is held on the Seattle campus. A number of students, graduates and undergraduates, are employed in the lab and, although their main research activity is in Redmond, they appear to have adequate opportunity to interact with their campus counterparts. The problem is not the campus/Redmond interaction; it is the future of the Redmond lab. The director, Alan Hoffman, announced that he would retire in five years. He is a very key person in the lab with no obvious replacement at hand. It is not at all too soon to begin consideration of the future role of the lab in the University and, if it is decided to keep the lab, to begin thinking about new leadership

7. **The College and the University should begin consideration of the future of the Redmond Plasma Physics Lab immediately.**

National Ranking

The most frequently cited ranking of graduate programs is that of the National Research Council issued in 1993. Of the 33 Ph.D.-granting A&A departments, the UW

department ranked 19th on the basis of faculty quality (see ADDENDUM 3). For comparison, UW Electrical Engineering ranked 25th among 122 and UW Mechanical Engineering was 31st among 110. The ranking quoted in the self study was the 2001 US News Graduate Ranking, which places UW A&A 18th among the 21 programs ranked. The US News rankings are based on reputation. Department chairs and senior faculty are asked to rank departments on a 1 to 5 scale and points are totaled to arrive at a ranking. The rankings all place UW A&A near the bottom of the second 10. As a goal, reaching the top 10 is not unreasonable, but as a practical matter it is not achievable any time soon. Reputations are slow to change, and the process of developing junior faculty into recognized scholars takes considerable time. In this regard, hiring senior faculty with established reputations is the quicker route.

A ranking of 19 does not preclude having an excellent instructional program and in having considerable success in placing graduates in good jobs. The committee recognizes both the high quality of the UW A&A instructional program and the success students at all levels have had in finding good employment. Apparently, our impression is shared by those who produced the US News rankings, since the 2001 ranking of "Best Undergraduate Engineering Departments with Ph.D. Programs" placed UW A&A 9th among 19 departments.

Space

In our opinion, Guggenheim Hall is an aging facility that should be completely renovated. In the 1988 NBBJ/TRA study it was among the campus buildings designated as "unsuitable for modern science." The 2001-2003 Capital Budget Request (ADDENDUM 4) contains an item of $300,000 for planning money to prepare for a complete renovation in 2005-07, but the prospects of this being funded are exceedingly poor. The space in the Aeronautical Engineering Research Building is of good quality, but the building is completely occupied. There is some prospect that Bioengineering, which occupies one floor of AERB, will move into Life Sciences II in the near future. Life Sciences II is also in the 2001-03 capital budget, but it will be built with private funding and the likelihood that it will be approved is fairly good. A&A is not as well positioned to take advantage of new space or of minor repairs money for building upgrades, as it should be. The committee toured A&A space and can certainly verify that, with the exception of AERB, it is in poor shape. On the other hand, a considerable amount of space seemed poorly utilized and was filled with old equipment not in use. Some of this could be put into long-term storage if a potential future use justifies the cost. Subsequent renovation of the space on an as-needed basis would be a relatively low-cost option that might satisfy the most pressing needs.

We make no pretense of having tried to balance the Department space needs against the available space nor were we presented with information that would have allowed us to do so. If the Department is to make a credible case for its space requirements, it should develop a detailed plan for research and teaching space needs for some time period such as ten years. Since most of the research space will be associated with new faculty, some acceptable figure for research space per faculty member should be adopted. For example, the NBBJ/TRA study gave 1150 ASF/Faculty as the average research space per faculty for competitive AA departments.

8. **The A&A Department should carry out a formal programming procedure for its space needs.**

Kirsten Wind Tunnel

The committee considers the Kirsten Wind Tunnel to be an exceedingly important element in the Department's program. Not only is it a superb instructional tool, it also supports both undergraduate and graduate research and is of considerable service to local industry. Add to this the fact that outside demand is sufficient to operate the facility on a self-sustaining basis, and it is easy to conclude that the wind tunnel is an important Department asset.

9. **The Kirsten Wind Tunnel should be maintained and its use expanded consistent with current student use.**

Instructional Program - Undergraduates

The number of undergraduates has undergone a rapid growth from a low of 59 in '97-'98 to 82 in '00-'01. This percentage growth is about that of A&A undergraduates nationally, so it would be difficult to determine the effect of any special efforts on the part of the Department to recruit undergraduates. The committee is on shaky ground in speculating on the cause of the increase, but most likely it is the perception of students that the aerospace industry is on the rise. Certainly their job experience would tend to support this view. This is not meant to discourage Department attempts at recruiting, particularly among disadvantaged minorities. Anecdotal evidence suggests that the AA101 course has attracted some undergraduates into the Department, although the value of the course is probably more in giving a wide range of students an exposure to the excitement of an engineering discipline than it is as a recruiting tool. Given the volatility of aerospace, it would be dangerous to extrapolate recent experience to enrollments in excess of 120 such as those that existed in '90-'91 and '91-'92. .

The emphasis on systems in the self-study can lead one to conclude that a fundamental change in the way students are taught is anticipated. There has been a change, but it is considerably short of being "fundamental." A systems approach implies a familiarity with the broad range of problems inherent in a project such as Aerosonde or a Boeing aircraft. It does not imply that "familiarity" with all problems is sufficient. The committee feels, as do the faculty with whom we've spoken on the subject, that breadth alone is insufficient and that systems engineers should have an in-depth knowledge of at least one specialty. For an undergraduate, this means a grounding in fundamentals and experience with a project of some scope. The systems part of the undergraduate curriculum is the design courses and they appear to work well.

The Committee met with six undergraduates recruited by the Chair and asked them to describe their backgrounds and their instructional programs. They were also asked whether they had had courses from adjunct faculty and how effective they found them as instructors. The responses were uniformly positive. All were interested and engaged in their studies. A Boeing engineer had co-taught a course several had taken and they were enthusiastic about the practical experience he brought to bear on the course. One student did remark that he would not like to see adjuncts solely responsible for a course, but said this without having had experience in a course with adjunct faculty as sole instructors. When asked about the high point of their undergraduate experience, the answer was the design course.

We did ask the one woman in the group as to whether she thought her gender was a disadvantage in a department that was predominately male. She bought a laugh when she began her remarks with the statement that "engineers are not noted for their social skills", but concluded that she felt both welcome and fully competitive with her male colleagues.

Several students remarked about the value of their co-op experience, but emphasized it was a difficult choice because the scheduling of required courses usually meant that the time to degree was extended. In all cases, students felt that a co-op experience was worth the extra time and some felt it should be required.

When asked as a group whether they would like to work for Boeing, the uniform answer was a vociferous NO! Some had relatives that had worked for Boeing and had left dissatisfied and others seemed to base their opinion on nothing more than the prevalent general low regard for Boeing among students. The recent Boeing engineers strike may have contributed to this feeling.

The committee found no reason to believe that the response from this group was in any way different from the response that would have come from a student group chosen at random.

Instructional Program-MSAA

The enrollment in the MSAA program has also risen over the past five academic years, but not as dramatically as the undergraduate enrollment. It also did not drop as much from the early 90's. The Department is concerned about the quality of the candidates it is able to attract although, from the point of view of job training, the candidates they do admit do very well. Symptomatic of their problem is the fact that of the 95 complete applications received for admission in Autumn 2000, 88 were admitted. The admission rate of 93% is in stark contrast to the rate for Engineering as a whole, 42.2% in 1999, or for a more highly ranked College of Engineering such as Cornell, 28.3% in 1999 (see ADDENDUM 5). GRE scores of entering students are not impressive. The Fall 1999 A&A numbers are 500 verbal, 597(is it really this low?) quantitative and 649 analytical. The Engineering numbers are 529 verbal, 726 quantitative and 654 analytical while the Cornell numbers are 568 verbal, 764 quantitative and 708 analytical.

The Department is attempting to improve its recruiting in a number of ways. Most important among these must be the effort to increase the amount of support available to new students. The current lack of research support outside the plasmas area is a major handicap. Until this is built up, they will find it difficult to compete with higher-ranked departments and will have too few attractive programs that can offer support to incoming students. Despite this handicap, they should follow their intentions to promote graduate opportunities on their web page, identify promising candidates early and give them personal attention by the faculty and promote visits to the Department. In connection with the latter, we recommend that:

10. The Department should consider a change in the way it brings prospects to Seattle. A weekend in which all the most promising candidates are brought to Seattle and paired with faculty has been found to be productive elsewhere on campus.

It is too late to organize such a weekend this year, but it is an opportune time to plan for next year and consult with other UW departments.

The Department hardly needs this advice from the committee, but it almost goes without saying that:

11. The Department should make every effort to increase graduate student stipends.

The committee spoke to a group of four MSAA candidates who, like the undergraduates, were all enthusiastic about their programs. Despite the fact that some of the students in this group had done first-class research, none were planning to go on to a Ph.D. Three of the four wanted to start what were likely to be very well-paying jobs and the fourth had a commitment to the Air Force. In one way they typify the problems the Department will have in building up its research program. MSAA students are

resident for less than two years on average and, although they may contribute to the research in an important way, they are gone too soon to provide continuity to research projects of longer duration. The Aerosonde project was cited by one staff member as a program, which, although very promising with high visibility, nevertheless had suffered from the episodic nature of graduate student efforts. Apparently, faculty did not provide the necessary continuity.

Instructional Program – PhD

The Department has no plans to increase the number of Ph.D. degrees awarded. This is probably a reasonable reaction to the flat or even declining demand for PhD's from industry, but it is counter to any attempt to build a stronger research program. If good, active faculty can be recruited to start new research programs, then it is likely, with appropriate effort on the part of the Department, that good students will follow. The three PhD students interviewed by the committee stated that they were all within six months of their degrees. Of the three, only one was supported by an RA, the other two had TA's. This has to be a discouraging situation for a student that puts in the extra years for the advanced degree. Although nothing will substitute for additional research support, the committee offers the following suggestion:

12. The Department should consider the possibility of enrolling PhD candidates directly without the requirement of an MSAA degree

Long the practice in many science departments, it is becoming more common in AA departments. Princeton is one example. This approach would probably not be a large departure from current practice. No new courses would be required and the prospect of a shortened time to degree might prove to be attractive. The 1993 NRC data show time-to-degree to be 8.5 years at UW and 6.6 years at Cornell.

EDGE

The EDGE program is of questionable value to the Department at present. The primary purpose of EDGE is to offer degree opportunities to industry employees by delivering courses to a location convenient to their workplace; a secondary purpose is continuing education. However, total enrollment of A&A students in EDGE courses has declined from 18 in autumn 1993 to 7 in autumn 2000. More recently, offerings have declined from 20 regular, graduate courses in the academic year 1997-98 to 11 offerings in 1999-2000. That year only 11 of 28 regular graduate courses were offered on EDGE, which raises the question of whether a student can expect to find the selection necessary to complete a degree program in a reasonable time. It may be possible to facilitate degree completion by developing programs of alternate year offerings of specific courses that lead to degrees in particular specialties and by promoting these programs to industrial students. We recommend that:

13. The Department should assess the value of continuing to participate in the EDGE program and, if appropriate, take such steps as will increase student participation and the opportunity for students to complete a graduate degree.

Faculty productivity – archival journals

The rate of publication for A&A as reported in the 1993 NRC rankings is 2.2/faculty/year, lower than all but four of the 33 universities in the report. The number for Cornell is 5.8/faculty/year and the average for the NRC quartile in which A&A finds itself is 3.5. The UW rate would appear to have dropped since 1993, but lack

of information on what the NRC considers a publication prevents us from confirming this. This result is not surprising in light of the level of research activity other than in plasmas. If that level increases so will the number of publications per faculty member. There is a conflict here that must be pointed out. If faculty are to be more actively engaged in research they will have to teach fewer courses. This will reflect on the range of subject matter that can be taught and will reduce the number of options, particularly for the graduate students. To some extent the impact of this can be lessened if appropriate courses can be found in other departments or courses can be shared with other departments through cross listing. A math course or a controls course or a fluid mechanics course taught in another department may not be taught in a way entirely appropriate to A&A, but the difference may not be worth the necessary A&A faculty time. A partial remedy might be to teach cross-listed classes in alternate modes in alternate years. Some specific possibilities suggest themselves in the list of courses taken by A&A majors in 1999-00 (ADDENDUM 6), but the Committee feels this selection is best left to the Department.

The Committee heard of several new courses that were being considered. They would undoubtedly be good from the students' point of view, but would only exacerbate what we consider to be a serious problem. For a research-oriented department, faculty in A&A spend too much time teaching. We recommend, therefore:

14. The Department should adopt the goal of one course per quarter as a teaching load for faculty.

This applies only to faculty with active research programs, so a policy of this sort would have to be phased in as new, more research-active faculty are hired.

Appropriate faculty size

If research is to assume a larger role in A&A and a reasonable range of courses is to be offered, the 16 faculty positions now in the Department are certainly not too many. On the other hand, a very different decision could be made. The Department could decide to play to its strength and concentrate on teaching. This is certainly not the direction indicated by the strategic plan, but were it to be considered the question of appropriate faculty size should be revisited.

Time to degree

The issue of the length of time taken to earn a degree was raised in connection with undergraduate majors. The Department feels that many, perhaps too many, students enter the AA program somewhat late in their education, hence, with more courses outside AA on their record than is necessary. This is somewhat borne out by the large number of A&A courses listed in ADDENDUM 6. However, the consequence of tightening up on this point could very well be fewer majors and that would not at all be in the interest of A&A. Also, the students pointed out the value to them of the co-op program and the effect this has on lengthening the time to degree. Offering courses more often would help the co-op program but would be very much counter to our recommendation to reduce the faculty teaching load.

Graduate time to degree was not mentioned, but we point to recommendation 12 as one way of shortening graduate time-to-degree for Ph.D. students.

Conclusion

As a Committee, we are impressed by how critical the decisions of the next few years are to the future of the Aeronautics and Astronautics Department. Their current circumstances permit them to aspire to regaining the stature they once had among UW

engineering departments, but the obstacles they face are formidable. They have both a good start on a strategic plan they can later revise and build on and the considerable advantage of dynamic leadership. The challenge will be to find the necessary resources. More will have to come from the University than has been the case and more will have to come through faculty efforts. The essential point is that substantial gains are possible if the University should decide to provide the necessary support.

Internal reviewers:

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William R.D. Wilson, Professor and Chair
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December 5, 2000

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Dear Mark:

RE: 10-year Review of Aeronautics and Astronautics

The specific action needed at the end of your review is a recommendation regarding the continuation of the Department of Aeronautics and Astronautics BS, MAE, MSAA and PhD degree programs. The range of possible recommendations runs from suspension of entry to continuation with a subsequent review in ten years. If you believe that a subsequent review of the Department should be conducted in less than the maximum period, please indicate at what time you suggest the next review be done and what specific improvements should be made in the intervening period. Perhaps more importantly than the specific recommendation of status and review period, your review has the potential to offer the Department and the administration an independent assessment of the health of the Department's programs and comment on how they might be improved.

The review is most likely to be successful if tasks are divided among the committee members effectively. It is suggested that the external reviewers be relied upon to serve as content experts, providing insight into directions of specific programs the Department and the respective fields are taking as well as assessing the national standing of the Department and its programs. The internal reviewers may be able to conduct some of their assessment and interviews prior to the day of the actual site visit.

The site visit will culminate with an exit interview divided into two portions, the first with the Chair and perhaps other program representatives present, and the second without these program representatives. The College Dean will be present at both sessions, as will the Deans and Associate Deans of the Graduate School and the Office of Undergraduate Education, and the Associate Provost for Academic Planning. Please let us know what your formal recommendation regarding continuance is likely to be early in the second period of the exit interview. We hope to have your report within 6 weeks of the site visit and to have the UW members of the committee attend a meeting of the Graduate School Council to present your findings and comment on the response of the Department. Augustine McCaffery will provide you with a model report if you would like. Please call upon her for any assistance you may need in the course of this review.

The most important objective of your review is an assessment of the academic and educational quality of the Department and its programs. The important questions are: Are they doing what they should be doing? Are they doing it well? How can they do things better? How should the University aid them? Each question can be asked in each sphere of operation. The test to apply in deciding how to prioritize issues is to consider how important each is to scholarship or education. It is important to realize that an assessment of the trajectory of the Department is more important than a simple analysis of its current state. Listed below are several issues that may help as you begin. This list is not intended to restrict your review; you should consider all issues that you deem to be sufficiently important.

General considerations

The Department of Aeronautics and Astronautics has had a distinguished history. It was initiated in 1930 and seems to always have had a close relationship with Boeing. It was one of the first such departments in the US. According to the self-study, its faculty has made several important contributions, not only to the field, but extending beyond.

The 1991-92 review indicated that the Department was not achieving what the review committee thought it could, particularly citing low faculty productivity and complacency. It is hoped that these conditions have been remedied. Your comments in this regard will be very valuable.

The Department.

1. Currently, according to the self-study, the graduates of the program are ranked by their employers to be as good as those of the very top programs in the nation (page 16), but the ranking of the Department by Deans of Engineering seems to be somewhat lower than might be expected from such comments (page 17). Without overvaluing rankings, is there a discrepancy that deserves comment?
2. Page 7. The Department is realigning from the traditional lines of aerodynamics, structures, controls and propulsion to a systems-based approach along the lines of aeronautical systems, space systems and energy systems. In undertaking this transformation, the Department appears to be planning a fundamental change in the way they teach their students. How is the transition faring with regard to educational and research programs? Your comments in this area are particularly important due to the very large turnover of faculty that is underway. Are these changes likely to help attract vigorous new faculty? Are there other structural issues that you feel deserve comment?
3. Please comment on faculty productivity. Some quantitative measures of performance (archival publications?) are given on page 48. What sort of performance to you expect to see in 5 years?
4. On page 43, the use of practicing engineers as adjunct faculty is commented upon. Please assess this feature of the educational programs. Is their role appropriate and complimentary or are they relied upon for more than should be expected?
5. The Plasma Physics Lab in Redmond is an obvious potential impediment to close integration with the Department. How well is it incorporated into the education programs and work of the Department? If this linkage needs improvement, do you have suggestions as to how it might be brought about?

6. To the extent that you are able, please comment on the interactions between the Department and other units on campus. Are there opportunities not recognized or exploited that come to mind?
7. Do you view the goals (page 53) to be appropriate, well prioritized and achievable? Is there a convincing plan by which they will be achieved?
8. Please carefully evaluate student satisfaction with instruction and other relationships with the Department and the faculty. Do students feel that the environment is supportive and conducive to learning? Are there issues of diversity that may be unrecognized?
9. Please consider the size of the faculty in relation to the demand for the Department's programs. What, in your view, is the appropriate size?

Undergraduate program.

1. On page 25, the Department describes a curricular change undertaken with the hope of decreasing the time to the BS by more logically ordering the sequence of courses. Although beneficial in other respects, the BS still takes about 5 years to earn. The Department concludes that 5 years is about what it takes. The external members of the committee ought to be able to comment on the national norm.
2. There have been other recent changes in the undergraduate curriculum as well, *e.g.*, AA 101. Your comments would be appreciated.

Graduate programs.

1. Please comment on the equivalence of the experience of the MS students participating through the EDGE versus traditional on-site instruction.
2. The graduate curriculum is in the process of being redone. Your assessment of the planned changes is likely to be helpful to the Department.
3. The ability to provide sufficient support seems to be a barrier (as it often is) to the recruitment of graduate students. Does the Department appropriately use research stipends to this end? Information on pages 38 and 40 of the selfstudy is relevant.

Sincerely,

John Slattery

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