UNIT SELF STUDY

DEPARTMENT OF AERONAUTICS & ASTRONAUTICS
COLLEGE OF ENGINEERING
UNIVERSITY OF WASHINGTON, SEATTLE

Bachelor of Science in Aeronautical and Astronautical Engineering (BSAAE)

Master of Science in Aeronautics & Astronautics (MSAA)

Master of Aerospace Engineering (MAE)

Master of Aerospace Engineering - Composite Materials & Structures (MAE-CMS)

Certificates:

"Aircraft Composite Structural Analysis and Design"

"Modern Aircraft Structures"

Year of Last Review: 2001

Chair: James C. Hermanson, Ph.D.

Date Submitted: November 23, 2011

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Department Mission

The mission of the Department of Aeronautics & Astronautics (A&A) at the University of Washington (UW) is to serve the region, the State of Washington, the nation, the profession, and society at large by attaining, and sustaining, the following goals:

1. To educate engineers for a lifetime of continuous learning and for contributions to all areas of aerospace engineering;
2. To provide a challenging and comprehensive education which develops necessary technical and professional skills, provides a solid foundation in the engineering sciences related to aerospace engineering, and develops engineering creativity through design experience and through research;
3. To expand knowledge by pursuing basic and applied research, by addressing critical technical problems related to aerospace engineering, and by devising innovative ways to develop and apply new technologies;
4. To contribute knowledge to, and participate in, the identification and solution of problems facing society; and
5. To work with local, national, and international aerospace and other industries to conduct joint research that advances the applications of new technologies and impacts engineering practice.

Department Degrees and Certificates

The A&A Department currently offers one undergraduate degree, three graduate degrees, and two graduate certificate programs. The Bachelor of Science in Aeronautical and Astronautical Engineering (BSAAE) degree goes back to the founding of the department in 1929. The department was originally named the Department of Aeronautical Engineering; “Astronautics” was added in 1962. The first Master’s degree program was initiated in 1946. Two Master of Science degrees are currently offered: the Master of Science in Aeronautics & Astronautics (MSAA) and the Master of Aerospace Engineering (MAE). The MSAA is primarily a continuing degree with two tracks, a research thesis or all coursework. The MAE is a terminal degree with an emphasis on industrial aerospace engineering practice, including skills vital in the aerospace engineering industry, such as business, management, manufacturing, and communication. The MAE degree has a variant with a specific emphasis on Composite Materials and Structures (designated MAE-CMS). Similar in overall structure and purpose to the MAE degree, the MAE-CMS is a practice-oriented, multidisciplinary master's degree program

for recent graduates and engineering professionals who wish to expand their knowledge or broaden their skills specifically in the emerging field of composite materials. The PhD program, established in 1959, is characterized by the comprehensive dissertation research expected and required in an aerospace engineering department at a major research university.

The two graduate certificate programs currently available are "Aircraft Composite Structural Analysis and Design" and "Modern Aircraft Structures." These programs are offered through UW Professional and Continuing Education (PCE), with additional sponsorship from Boeing Learning, Training and Development, Engineering Operations Group (LTDE).[1] The highly-popular certificate in Aircraft Composite Structural Design and Analysis is intended to provide Boeing engineers and vendors state-of-the-art training in the design of composite structures. The certificate consists of three courses in mechanics, analytical methods and design case studies, covering a broad spectrum of theoretical and practical developments in the field. The certificate program in Modern Aircraft Structures covers theoretical and practical developments in the field through courses in design and analysis, finite element methods, fatigue and fracture; the program also includes design and analysis projects. Certificate program courses are taught in classrooms at Boeing facilities by UW faculty, Boeing subject matter experts, and leading professionals from the FAA. Since its inception in 2005, these programs have graduated over 200 students from Boeing and its partners.

The undergraduate program is conducted entirely on campus, with the exception of internships, co-ops, and similar projects and activities. The master's programs may be taken on campus or off-campus. The latter is made possible by offering all graduate courses via distance learning through PCE, which provides multimedia and class-capture services. This flexible solution for working professionals allows students to continue their education on their own terms using on-line video-based classes. The quality of education these students receive is identical to that which the on-campus students receive.

Enrollment and Graduation Patterns

Enrollment during the 1980s was at capacity levels for that time, with 120-140 undergraduates and 120-140 graduate students, with many qualified students turned away. Those levels dropped considerably by the mid-1990s, as a result of the recession the aerospace industry experienced at the end of the cold war. Enrollment in the undergraduate program began to recover in the late 1990s, and enrollment in the graduate programs stabilized in 2000, with significant growth in recent years. Enrollment and graduation statistics over the past ten years for each of the programs in A&A are presented in Appendix E (figure numbers cited below refer to that Appendix).

The undergraduate population was roughly constant between 2000 and 2007 (Fig. E-1). Since 2008 enrollment has steadily increased, and in 2011 it is now approximately 29% higher than the 2000-2007 average. Historically, the BSAAE degree program has been an upper-division only (i.e., junior and senior) program. Beginning in the late 1990s, the department began a process of inviting high-achieving, lower-division students to join the department at the start of their

[1] http://www.pce.uw.edu/certificates/modern-aircraft-structures/other---in-state-autumn-2011/

sophomore year as Early Admission students. The number of Early Admits entering the department increased significantly in 2006, as seen in Fig. E-2, but has been roughly constant since that time. Currently, about 25% of students in the junior class were originally admitted through the Early Admission process. Some increase in undergraduate enrollment is due to an experimental admission process, called Advanced Admission, which was initiated by the College of Engineering in 2008 but discontinued in 2011. This process allowed selected students to enter an engineering program of their choice at the end of their freshman year. Further, 2011 is the first year of Direct Freshman Admissions in our department, a process which admits a limited number of freshmen to the department at the start of their freshman year. These various admission data are summarized in Fig. E-2.

The graduate program in the A&A department has significantly increased in size over the past ten years, from 76 students in 2000-2001 to 131 in 2010-2011. That number jumped to 150 in Autumn 2011. The master's programs have grown from an enrollment of 47 in 2000 to 107 in 2011. Much of this growth is due to the large increase in participation in the distance-learning programs, which grew from 11% to 23% of graduate enrollment between 2001 and 2005, and currently comprise 35% of all graduate enrollment. The number of PhD students in the department averaged 35 between 2004 and 2010; this number increased to 47 in 2011.

The graduate program in the A&A department has significantly increased in size over the past ten years, from 76 students in 2000-2001 to 131 in 2010-2011, as can be seen in Fig. E-3. That number jumped to 150 in Autumn 2011. The master's programs have grown from an enrollment of 47 in 2000 to 107 in 2011. Much of this growth is due to the large increase in participation in the distance-learning program, which grew from 11% to 23% of graduate enrollment between 2001 and 2005, and currently comprises 35% of all graduate enrollment in the program. The number of PhD students in the department averaged 35 between 2004 and 2010, but increased to 47 in autumn 2011. Figures E-5 and E-6 provide additional data on graduate admissions and graduations during the 2001-2011 period.

The fraction of underrepresented minorities (URM) in the A&A undergraduate program, shown in Fig. E-4, fluctuated between 3% and 8% between 2002 and 2007, but decreased beginning in 2008, possibly due to the unfavorable state and national economic conditions. Currently, URM enrollment comprises 4% of the undergraduate enrollment. The enrollment of women increased steadily beginning in the 1990s, and grew to represent about 23% of the undergraduate program in 2004 and 2005. However, it has declined during the past six years, and the current level is only 12%, for reasons that are unknown. Underrepresented minorities in the graduate program have increased from 1% in 2001 to 10% in 2011, as can be seen in Fig. E-7. The number of women in the graduate program increased from 13% to 16% over the same period.

Academic and Non-academic Staffing

The A&A Department is staffed by a faculty of 16 FTE faculty positions, one of which is vacant due to a resignation in August, 2010. Details about the faculty, including brief CVs, are found in Appendix C. The current breakdown by rank is as follows:

10 Professors:	Breidenthal, Bruckner, Hermanson (Chair), Holsapple, Jarboe, Kurosaka, Livne, Lin, Mesbahi, Shumlak
2 Associate Professors:	Dabiri, Morgansen
3 Assistant Professors:	Feraboli, Ferrante, You

The department has two non-tenure-track faculty (Milroy, Research Professor; Slough, Research Associate Professor). These appointments are without teaching duties. The department currently has nine emeritus faculty (of whom three are active in research), three adjunct faculty (one each from Earth and Space Sciences, Mechanical Engineering, and Oceanography), and twenty affiliate faculty from industry or other universities and organizations. Several of our faculty have adjunct appointments: Mechanical Engineering (Dabiri, Hermanson), Electrical Engineering (Morgansen), Mathematics (Mesbahi), and Physics (Jarboe). Among the faculty are three AIAA Fellows (Bruckner, Christiansen,[*] Russell[*]), two ASME Fellows (Hermanson, Kurosaka), two APS Fellows (Jarboe, Russell[*]), and one Fulbright Senior Research Fellow (Decher[*]).

The organization of the A&A Department faculty broadly reflects the fields of aeronautics and astronautics, also known as aerospace engineering, which is concerned with the design, analysis, construction, and integration of vehicles for atmospheric and space flight, such as airplanes and spacecraft. A broad spectrum of engineering sciences underlies the field, such as aerodynamics, structural mechanics, propulsion, controls, flight mechanics, space dynamics, and plasma physics. In recent years, multidisciplinary systems analysis and integration have become increasingly important aspects of the field.

The faculty are broadly organized into four disciplines: Controls (Mesbahi, Morgansen), Fluids and Propulsion (Breidenthal, Bruckner, Dabiri, Ferrante, Hermanson, Kurosaka), Plasma (Jarboe, Shumlak, You), and Structures (Feraboli, Holsapple, Lin, Livne).

The department is directly supported by an administrative staff of 16, broadly grouped into administrative, academic advising, fiscal, technical support, computing, and Wind Tunnel.[**] The department chair is directly supported by a chair's assistant and the department administrator, to whom three fiscal staff report. The undergraduate and graduate programs each have dedicated advisors. In addition, the expanding distance-learning graduate program is assisted by a half-time program coordinator. Technical support for the department's education and research functions is provided by one mechanical engineer, one electronics engineer, two instrument maker/machinists, and two computer specialists. The Wind Tunnel is served by a manager who is in turn supported by a research engineer. Additional technical staff (research scientist/engineers and technicians) are employed directly by various researchers and programs in the department. Please refer to the complete organization chart provided in Appendix A.

[*] Emeritus faculty.

[**] Known as the University of Washington Aeronautical Laboratory (UWAL).

Governance

Governance is centered on the faculty, led by the chair. Faculty decisions are generally made by vote or consensus. Administrative and policy decisions are made by the chair in consultation with faculty and staff.

The department is also guided by a Visiting Committee that consists of 16 national aerospace experts from leading academic (5), industrial (8), and government and other institutions (3). Although budget constraints have limited its activities, we plan to reconvene this Committee in 2012. A list of committee members is attached as Appendix F.

Budget & Resources

Departmental Budget Summary

Total expenditures for A&A in FY2011 were $12.3 million, roughly twice the amount expended in 1999-2000. The department has been successful in continuously bringing in research funding and developing its distance-learning programs, and has been fortunate with its alumni donors. Distance learning, plus certificate programs not envisioned at the time of the last review, grew from a projected net cost to total positive program revenue of $684,344 in the 2010-2011 biennium. Research expenditures per year have doubled in the past ten years ($3.9 million in 2000 to $7.6 million in 2011). The Boeing Endowed Professorship, unassigned since 2005, has accumulated $365,000 in operating funds, which will likely be used toward start-up funding for a planned new faculty hire. The Boeing Endowed Fellowship (currently endowed with $635,000) provides a full graduate fellowship, crucial for competitive student recruiting. In addition to funding four undergraduate scholarships, the Reynolds Endowment has supported expansion of the Airplane Design capstone course series with funding which peaked at $30,000 in 2010, transforming the course into a nationally-acclaimed program.

Together, the sources identified above have allowed the unit to maintain its operating posture, and even to expand in some areas, in spite of local effects of the reverses in the national and state economies of the last four years. State allocations to the department, which grew slowly following the last review, have in the past two years dropped by nearly 15% and are poised to fall further in 2012. Endowment distributions were reduced 25% in FY09 and 25% again in FY10, restricting scholarships and operations. Additionally, the distribution of indirect cost returns to the A&A Department was changed by the College of Engineering in 2007, resulting in a permanent decrease in operating funds of approximately $100,000/year.

In response to these fiscal challenges, we removed 9.3 FTE of staff positions from our General Operating Fund (GOF) budget: staff salaries that remain on that state budget today are at 62% of the 2000 level. Several positions (7.25 FTE) are now supported by other department resources or self-sustaining budgets. The GOF budget allocation for Teaching Assistant (TA) support was reduced from $414K in the 2003-05 biennium (earliest data now available) to $50K in the current biennium. The reduced cadre of TAs (currently approximately 10/quarter) costs at present $361,912 per biennium without tuition (i.e., when paid on the GOF budget with attendant tuition waivers). To free GOF funds to provide this level of teaching support, faculty salary is

transferred to the departmental revenue budget which receives the distance learning program profits. An additional $221,000 in funding for auxiliary instructors will be required for the current biennium to teach courses for which the faculty line is presently vacant or which do not have a tenure-track faculty assigned. As the GOF budget lacks any allocation for such functions as lab and computer upgrades, graduate recruiting, seminars, capstone courses, staff training, and more, these activities are now restricted. Funding for these items is covered by 75% of the income of the Weiberg endowment, which also covers mundane requirements such as office supplies and services. A regular seminar series was discontinued in 2008 due to costs; occasional special seminars or speakers are now supported by the Abraham Hertzberg endowment. Certain courses have been rescheduled to be offered in alternate years, or are not offered, for financial reasons. Although these strategies have allowed us, for the most part, to protect the quality and scope of our programs, they absorb resources that would otherwise have supported new faculty hires, teaching and research initiatives, support for students in the form of teaching assistantships, and upgrades of facilities. Please refer to the budget summary in Appendix B.

Funding Acquisition Strategies

Approaches to increasing the level of funding are identified in the A&A Department Strategic Plan of 2009. Specific items contained in that plan include increasing the annual number of proposals for MURIs, IGERTs, and center grants and establishing a "red team" within the department to review proposals to increase their chances of success. The plan also calls for increasing the prospects of external funding by increasing the number of cross-university collaborative efforts by establishing research centers that attract the participation of faculty from outside the department. The plan also includes the goal of establishing ongoing working relationships with NSF, DOD and other government research agency program management.

The A&A Department is also seeking to increase the level of industrial funding by establishing long-term, strategic partnerships with local and national aerospace companies. The department is also exploring the possibility of an industry-sponsored department naming, which would be expected to result in significant additional resources. Finally, the department will continue to work closely with the Advancement Office in the College of Engineering to secure additional gifts from department alumni and other key potential donors.

Best Use of Funding and Resources

The effectiveness of the department's use of its resources is assessed by the department chair with advice and inputs from the faculty and the administrative, advising, and technical staff in the department. Priorities in the use of resources are evaluated to ensure that they are in line with the department's strategic plan, with inputs from the Strategic Planning Committee (previously the department had a Budget Committee to perform this function). Based on the strategic plan, available funding, and advice from the various constituents in the department, the chair makes the final budgetary and human resources decisions.

SECTION II: TEACHING & LEARNING

A description of our ABET-accredited undergraduate BSAAE degree can be found on our website: http://www.aa.washington.edu/admissions/undergrad.html and the undergraduate curriculum is available at http://www.washington.edu/students/crscat/aa.html (the UW course catalog). Historically, most students have entered the program in their junior year, to facilitate transfers from the state's community colleges and to ensure students successfully complete prerequisites prior to matriculation. However, shortly before our previous academic program review in 2000-2001 the department developed an early admission program, whereby highly qualified students are accepted as sophomores. In addition, beginning with the 2011-2012 academic year, a small number (~10% of junior enrollment) of exceptionally qualified high school graduates began to be admitted directly as freshmen.

A description of all of our graduate degree programs can be found on our website, http://www.aa.washington.edu/admissions/grad.html, and details of the graduate curriculum are in the UW course catalog: http://www.washington.edu/students/crscat/aa.html.

Student Learning Goals and Outcomes

The goals and objectives of the undergraduate program are to provide a challenging and comprehensive education, a solid foundation in the engineering sciences related to aerospace engineering, and a strong systems perspective; to develop engineering creativity through design experience and the necessary functional skills and understanding of the societal context in which engineering is practiced; and to prepare graduates to succeed in engineering careers and to instill lifelong learning. The expected outcomes for graduates are that they will be skilled in engineering fundamentals, engineering design, laboratory skills, synthesis of various engineering disciplines, and working in a team environment. Graduates are expected to be highly regarded by employers in aeronautics, astronautics, energy systems, and related fields. They will develop strong interpersonal skills and a desire for life-long learning that will help them succeed in their chosen careers. Graduates will be valued at local, national, and international industries, as well as at government organizations and institutions of higher learning.

The goals and outcomes for our graduate students build on those for our undergraduates, with the additional expectation that their specific graduate degrees will give them a more in-depth and advanced academic view of the concepts of aeronautical and astronautical engineering, and, for MSAA degrees with theses, a significant research component. PhD graduates conduct in-depth scientific research leading to substantial and original research contributions. The outcomes of each specific graduate degree program are:

- MAE graduates will emerge from the program with the practical engineering skills needed in industry and the essential project management skills to advance professionally.
- MAE-CMS graduates will have gained the practical engineering and project management skills necessary to become leaders in the growing field of composite materials, as applied to the commercial airline industry.

- MSAA graduates will have in-depth knowledge in their specific area of interest and will be able to pursue advanced degrees, or careers in industry, government, or the engineering sciences.
- PhD graduates will be able to pursue leadership roles in academia, industry, and at top engineering research institutions.

Evaluation and Assessment of Student Learning and Satisfaction

The undergraduate and graduate programs use a variety of similar methods to evaluate student learning (see Table 1 below). On a quarterly basis, the grades of each student are assessed and compared with course averages, while noting trends, variances, and consistencies from year to year and in comparison with other courses in the department. Other methods of evaluating graduate student learning in the department include tracking awards and external recognition, publications, conference presentations, and progress in taking milestone exams (for PhD students). In undergraduate classes, a variety of methods are used in the classroom to assess learning on an ongoing basis such as weekly pop quizzes, individual student-instructor and student-TA conferences, etc. The table below notes some of the primary methods that are used to assess student learning in each specific degree.

In addition to the above, the overall student learning and integration of skills at the end of their undergraduate program are assessed as part of their participation in either of the two required capstone senior design projects (one in Aircraft Design, the other in Space Systems).

Table 1. Methods of evaluation of student learning

	Course evals	**CIDR* feedback & evals**	**Exams****	**Course grades**	**Publi-cations**	**Conference presentations**	**Awards & external recognition**	**Entrance & exit interviews & surveys**
BSAAE	✔	✔	✔	✔			✔	✔
MAE	✔		✔	✔			✔	
MAE-CMS	✔		✔	✔			✔	
MSAA	✔		✔	✔	✔	✔	✔	
PhD	✔		✔	✔	✔	✔	✔	

*Center for Instructional Development and Research

**For PhD candidates, exams include qualifying and general exams, and defense of dissertation.

All faculty undergo periodic reviews of their teaching performance by a committee of senior faculty in the department. These reviews are conducted annually for assistant professors, every second year for associate professors, and every three years for full professors. Further information on the peer-evaluation process is provided in Appendix G.

Student satisfaction with the undergraduate program is assessed by a variety of methods, both formal and informal. Juniors and seniors are surveyed at the end of each academic year with a Catalyst survey that interrogates their level of satisfaction with the program. CIDR also conducts an in-class review of the program in the spring for both the juniors and the seniors that

addresses satisfaction with the program in areas such as academic standards, adequacy of training and facilities, quality of the faculty and mentoring, career preparation, etc. Other methods of assessment include the informal communication between students and faculty, with the staff adviser, and by surveys at different times during the undergraduate program and after graduation. The department also surveys its alumni four years after they have graduated, to assess how well the program is serving their career goals. Underrepresented minority (URM) students are surveyed by the same process as all other students.

The Graduate School requires that students complete an exit questionnaire upon graduation from the University. In the questionnaire, students are asked to rank their satisfaction with the program in the same areas as the undergraduate program survey, with an additional emphasis on research capabilities. Those data are presented in Appendix E. The A&A Department uses the collected data to assess the satisfaction of our students relative to both the College and the University as a whole. Other methods used to evaluate student satisfaction with the department include one-on-one communication with students by faculty and staff advisors, an informal survey of the A&A graduate student association and Graduate & Professional Student Senate representatives, and feedback from alumni, with whom relationships are nurtured by the department. As with the undergraduate program, URM student satisfaction is not assessed any differently from other graduate students, but efforts are made while they are in the program to ensure that they find support through campus organizations (such as WISE, SWE, and GOMAP)[*] to enhance their experience in the department.

Evaluation and Assessment Findings

Students report that they are typically pleased with their undergraduate program in the A&A Department. However, there have been some comments about the undergraduate lab classes being too intense and lengthy, particularly with respect to the lab report requirements. Although in alumni surveys there are sometimes comments on how the lab reports were dreaded, most alumni, particularly those involved in experimental or testing work, have stated they were much better prepared than their peers from other institutions and were thankful that they had had the experience. As has been the case for many years, more hands-on experience continues to be desired; however, due to budget constraints, it may be difficult to implement additional hands-on activities in our undergraduate courses. Surveys indicated that some students felt that some two-quarter courses cover materials that could be covered in one quarter. The undergraduate curriculum is being reviewed this year, and some restructuring is expected to take place. Overall, the undergraduates find that they are much more prepared for the workforce than most of their peers.

As shown in Appendix E, the graduate students in our department are quite satisfied with the quality of our program, particularly at the master's level, where in the last several years our department's ratings have exceeded those of both the College and the UW as a whole. The areas which PhD students give the lowest marks are in preparation for teaching and career mentoring. In all cases, students are pleased with our academic program as based on an average overall

[*] WISE: Women in Science and Engineering; SWE: Society of Women Engineers, GOMAP: Graduate Opportunities and Minority Achievement Program

ranking of the quality of the program over the last ten years of 4.0/5 by master's students and 4.05/5 by doctoral students.

On an anecdotal level, we hear often from our alumni (undergraduate and graduate), many of whom have been very successful professionally (see Appendix H). These former students tell us that with the perspective gained from being in the workforce, they highly value the education they received here and have put many of the lessons learned in our department to practical use on their jobs.

Improvements

The findings gleaned from our surveys of undergraduate students and alumni have led to a variety of curricular changes in our undergraduate program, which are listed in Appendix I. Further, as mentioned above, the undergraduate program is undergoing review this year and some restructuring is expected.

The outcomes of the graduate program assessments mentioned above have led to an almost complete revamping of the graduate curriculum over the last five years (see Appendix I: Course Changes). Many of these changes resulted in course content that was more comprehensive and state-of-the-art to prepare students for research and work in industry. Issues relative to teaching and career mentoring mentioned above are being addressed in new programs for teaching, mentoring and evaluation, including more opportunities for PhD students to serve as course instructors. Another outcome was the creation and funding of A&A graduate student organizations, such as the Graduate Student Social Committee and the A&A Graduate Student Organization (both UW-registered groups). These groups plan events to encourage graduate/faculty mentoring and camaraderie (such as a brown bag lunchtime seminar series, wine and cheese receptions, picnics, hikes, etc.). The events, attended by graduates, faculty and staff, have resulted in greater collegiality among these groups.

Non-major Undergraduate Learning

A&A majors are not our only constituents. The department offers two Engineering Fundamentals courses, AA 210, Statics (offered Autumn, Winter, and Summer), and AA 260, Thermodynamics,[*] (offered Spring and Summer). The topic of Statics is required by all but four departments in the College of Engineering, and Thermodynamics is required by A&A and is an option for two other departments, MSE[†] and ISE[†]. These courses are typically taken by A&A applicants in their sophomore year, but non-A&A majors may take them later to meet their departments' graduation or electives requirements. The learning goals in these courses are the same for all students, regardless of intended majors. Undergraduates from other departments (predominantly engineering) also participate in a number of the department's graduate courses (e.g., AA 547, AA 570, as well as doing undergraduate research as AA299/AA499).

[*] The department took over this course from Chemical Engineering in 2010, when that department dropped it and replaced it with one more attuned to its field, as well as to Bioengineering and Biology.
[†] MSE: Material Science and Engineering; ISE: Industrial and Systems Engineering

Instructional Effectiveness

Methods to Evaluate Instruction Quality

Each quarter, students also complete comprehensive institutional course evaluations for each course. Faculty receive this anonymous feedback and use the results to assess the effectiveness of their teaching methods relative to learning goals. The UW Center for Instructional Development and Research (CIDR) as well as the Center for Engineering Learning and Teaching (CELT) provide additional resources that A&A faculty use to evaluate the teaching and learning in their classroom, including course syllabus and assignment design, classroom observation and critique, etc. Further, the A&A Department has developed a self-evaluation form for instructors to evaluate their own courses. This process not only allows them to reflect on how well the class went, but how they could improve it the next time they teach it. The process also helps other instructors to determine what material was covered, should they be teaching a subsequent offering of the course, and helps in planning. Each undergraduate course is required to have a course evaluation from the Educational Assessment Center. Further, staff from CIDR or CELT are invited each year to interview the junior and senior classes to assess the quality of instruction. The results of the faculty peer evaluations of teaching, growth in course enrollment/popularity of classes, and interdisciplinary enrollment in courses are also considered.

Training in Teaching

Graduate students attend an annual UW TA workshop and attend recommended UW sessions on teaching. The students are trained for individual classes by the course instructor, are given job descriptions, and are evaluated at the end of the first two quarters. Instructors (faculty, postdocs, and graduate students) are given the opportunity to participate in teaching symposia, to receive CIDR/CELT consultations, and are mentored by senior faculty.

Postdocs and senior graduate students in the department have taught some service courses (e.g., AA 210, Statics) and junior-level core courses (e.g., AA 311, Introduction to Flight Mechanics) with good success. Peer mentors, as well as senior faculty members, are made available for guidance to those postdocs and graduate students who have not previously taught.

Instructional Changes Due to Evaluation

Faculty have introduced group projects into their undergraduate classes to encourage more interactive learning. In some cases two or more faculty teaching different core courses have collaborated to develop projects that are common to their corresponding courses. New instructors, including postdocs and graduate students who teach, are encouraged to create non-graded pop quizzes to understand if the students are learning what they are expected to. This method benefits the new instructors and the students by bringing each party to the same level of expectations. At both the graduate and undergraduate level, there is much greater use of online tools now than at the time of the previous program review. In particular, lecture material (lecture notes, homework, examples of worked problems, etc.) is often provided online and the use of online chat areas is encouraged for student problem-solving sessions.

Teaching and Mentoring Outside the Classroom

Faculty Involvement in Learning Outside the Classroom

Faculty supervise graduate and undergraduate students in research projects for independent study and theses/dissertations, and mentor these students. Many faculty members also serve as mentors to students through CWD,[†] MentorNet, etc. Faculty participate in outreach activities such as Bridge (summer program for STEM students, predominantly URM), DO-IT[†], Summer Math Academy, SpaceGrant SURP[†], and REU.[†] They present special seminars, participate in Engineering Discovery Days, STEM activities, etc. Faculty also encourage undergraduates (freshmen through juniors[*]) to participate in extracurricular project activities, such as the annual AIAA Design, Build, Fly (DBF) competition, and more recently NASA's University Student Launch Initiative (USLI). Graduate students have also participated in the annual competition hosted by the Experimental Sounding Rocket Association (ESRA).

Recruitment

The Undergraduate Program Manager participates in a number of recruitment activities throughout the year, such as College of Engineering Discovery Days, "Sundaes on Wednesdays," and information sessions. The undergraduate seminar, AA 496 (held during winter quarter), was redesigned to recruit and inform freshmen and sophomore students about the field of aerospace engineering and provide them with additional information about the major. The Undergraduate Faculty Advisor attends the yearly Society of Black Engineers dinner function. In addition, the department participates in the Bridge program each summer for incoming (predominantly URM) students in STEM, has a number of faculty-mentored projects for undergraduates at all levels through the NASA SURP program, and provides tours of the A&A labs and the Kirsten Wind Tunnel for high school students. During the summer similar tours are conducted for the Museum of Flight's Washington Aerospace Scholars Program (for high school students). Throughout the academic year the student chapter of the AIAA organizes outreach activities to K-12 schools in the Puget Sound area. All these activities have been effective in attracting students to the undergraduate program.

To recruit students to our graduate program, A&A employs a variety of methods. Since our webpage is generally the first place that prospective students visit when they are evaluating our program, we have worked hard to ensure that the content is engaging, informative and user-friendly. During the department's web redesign in 2009, the graduate advisors worked closely with a web designer to build a site that would showcase our research and academics, enticing prospective students to explore the opportunities available at UW. Additionally, we have used other technologies, such as chat and social media outlets, in order to build a stronger web presence. The graduate program also uses more traditional methods of recruiting students, such as attending local and national graduate school fairs, contacting self-identified undergraduate

[†]CWD: Center for Workforce Development; DO-IT: Disabilities, Opportunities, Internetworking, and Technology; SURP: Summer Undergraduate Research Program; REU: Research Experience for Undergraduates; STEM: Science, Technology, Engineering, and Mathematics.

[*]Seniors are not permitted to participate because of the effort they must invest in their senior capstone design courses.

aerospace engineering students whose names are obtained through various graduate school recruiting agencies, and presenting workshops on applying to graduate school to our own undergraduates. Through these efforts, each of the two graduate advising staff field hundreds of inquiries per year by phone, email, chat and in-person. Our faculty also contribute to the recruitment process by interacting with prospective graduate students at various conferences, lectures, and campus visits.

In order to recruit a more diverse student body, the department works with several internal and external groups. Within UW, we work closely with GO-MAP, Space Grant Consortium, and the STEM Bridge program for first-year engineering students. At the graduate level, we also receive mailing lists for minority students interested in pursuing graduate degrees in aerospace engineering from external organizations, such as the National Name Exchange and the McNair Scholars Program. We attend graduate school fairs that focus on URMs and meet with groups, such as the Society for Hispanic Professional Engineers. Currently we have several minority students who serve as peer recruiters and are helping to expand our minority recruitment program. Our efforts have been effective, as our URM enrollment has increased five-fold since 2001. We also consider women to be a minority in engineering, and we have made inroads in this area as well: our population of female graduate students has nearly doubled in the last ten years, and the same is true for our undergraduate program.

The department is also a participant in the NSF Center for Sensorimotor Neural Engineering (CSNE), one of four Engineering Research Centers inaugurated this year. The CSNE specifically addresses research for persons with disabilities and includes several minority-serving institution research partners (San Diego State University, Morehouse, Spelman, Southwestern). An explicit goal of the CSNE is to increase participation of women and URM in STEM disciplines via research and outreach activities in the Center and further to provide a national template for leadership of women, people with disabilities, and other under-represented groups in engineering.

Student Academic Support and Progress

Faculty provide office hours for students and meet with them as needed. TAs conduct regular study sessions. If students have difficulty, they are encouraged to meet with faculty or staff advisors. Students with learning challenges have been referred to the study skills classes through the UW counseling center, and we have assisted them with finding tutors. Students are mentored in research labs by other, more senior students. We have a fair policy and process for notifying and working with students who are not making satisfactory progress. The result in the undergraduate program is that the attrition rate, from the time students enter the department (which typically happens at the beginning of the junior year for the majority of students) until they graduate, is negligible.

One of the goals of the department graduate program is to provide education to students from non-aerospace backgrounds (e.g., computer science, physics, math) which, in many cases, includes a number of URM students. We provide tailored guidance and mentoring for meeting pre-requisite course material leading to education at the graduate level in A&A.

Students receive a solid education in analytical and engineering fundamentals as well as learning about current issues and developments in aerospace through regular seminars. They have opportunities to perform research, and to present the results of their work within and outside the university. Our students work individually and as part of teams on challenging projects in courses, in research labs, and in extracurricular activities such as the annual AIAA Design, Build, Fly (DBF) competition and the newly developed USLI rocket group. Students are encouraged to interact with one another as well as with faculty and to freely exchange ideas. Our students are prepared for successful careers in diverse sectors of the economy, from Boeing to NASA to educating the next generation of engineers at other prestigious universities around the world.

The department also works with the Center for Career Services and directly with various employers to provide information to A&A students on deadlines for submission of resumes, on company information sessions, and on the annual Career Fair. The Center also provides a number of workshops to which students are referred in order to prepare themselves on how to write resumes and to brush up on their interviewing skills.

The undergraduate faculty and staff advisors meet with students as early as their junior year to discuss graduate school opportunities, either at UW or elsewhere. A seminar titled "How to Apply to Graduate School" is presented to juniors and seniors. The undergraduate faculty advisor also reviews students' resumes and statements of purpose. The advisors build relationships with employers and serve as liaisons between companies and prospective student hires. Data on undergraduate and graduate employment can be found in Appendix E.

Section III: Scholarly Impact

Introduction and Overview

A&A faculty and their students have historically made major, internationally-recognized contributions to aerospace and engineering technology. For example, pioneering work in collaboration with Boeing and the University of California played a key role in the development of the finite element method, one of the main computing tools of modern scientists and engineers tackling large-scale field problems in structural mechanics, acoustics, fluid flow, electromagnetics, and plasma dynamics. What is widely considered to be the first paper on the finite element method, published in 1956, was co-authored by Prof. Harold Martin of our department.

Originally led by Prof. Abraham Hertzberg, the Aerospace and Energetics Research Program (AERP) was established by a grant from NASA in 1967 to carry out leading-edge research on space and energy systems. Early work on key elements of high-power gasdynamic lasers and their applications, and other key technologies, evolved into our current Plasma Science, Ram Accelerator, and Shock Wave Reactor programs, among the most successful in the College, and also several projects to develop advanced technology for space and terrestrial energy. All of these endeavors have gained broad international recognition as highly innovative and promising technologies for the future. The formal integration of AERP with the department resulted in a unique mix of traditional aerospace fields (controls, fluids, structures) with nontraditional fields

(plasma and energy), which distinguishes the department from other aerospace departments at peer institutions.

The primary measures by which we gauge our performance in research, scholarly, and creative activity are: leadership in field; quality and number of publications; and vitality of research programs/funding levels. With these measures we are recognized as leaders and principal innovators in several important disciplines in aerospace. Most notable are major advances in the fields of unmanned air and space vehicles, turbulence/vortex dynamics, plasma dynamics and fusion, composite materials, and multidisciplinary optimization.

Contributions from the Discipline Groups

An approximate division can be identified between the discipline groups of controls, fluids, plasma, and structures. Highlights of the scholarly impacts of the research from each of the discipline groups are described below.

Controls Group: Over the last decade, controls research has moved forward on several fronts, most notably in terms of the range of its applications in diverse disciplines, including networked aerospace systems, bio-inspired motion planning/control, advanced optimization techniques for trajectory planning and control, unmanned autonomy in air, space, underwater, ground robotics, with a multitude of civilian and military applications. Funding in controls reflects these trends, with generally less funding for foundational theoretical work in controls that is not directly linked to a specific application area (with a few exceptions) and more opportunities in novel applications of the existing paradigms in new settings that are relevant and promising. Our faculty are nationally and internationally recognized leaders in several of these developing novel areas.

Professor Mesbahi has published a textbook on Graph-theoretic methods in multiagent networks (Princeton, 2010) as well as collaborating with Fred Hutchinson Cancer Research Center on dynamics and control of genomic networks (published in *Proc. of National Academy of Science*) and with Boeing and UW colleagues on control/optimization issues related to smart grid and energy management. Professor Morgansen is currently leading a MURI on bio-inspired agile flight (ONR) with 10 other co-PIs (including four biologists) at four other institutions. She is also collaborating with biologists on additional projects in bio-inspired flight and with engineers, biologists and neuroscientists in the NSF-funded Center for Sensorimotor Neural Engineering (CSNE), serving in a leadership role as thrust leader for Forward and Reverse Engineering. The CSNE is a multi-university center led from UW and partnered with MIT, San Diego State University, Spelman University, the University of British Columbia and the University of Tokyo. Additional collaborations are in development with Queensland University of Technology through a Study Abroad course focusing on URM students as well as a proposed graduate student exchange through the NSF East Asia and Pacific Summer Insitutes program.

Fluids Group: The research activities of the fluid dynamics group have produced many important first discoveries in the area of turbulence and vortex dynamics and have pinned down mechanisms which had defied earlier attempts. These contributions include theories of free turbulent mixing, stratified entrainment, accelerating jets, confined turbulent mixing, and

buoyancy-reversal instability [Prof. Breidenthal (PI)]. Also among the credits of this group are compressor flutter analysis, multiple pure tone (MPT) noise from gas turbine engines, definitive theory and experimental verification of the Ranque-Hilsch tube (vortex tube) effect, total-temperature separation in jets, corewise transport in vortices, anti-kidney vortices in crossflow jets, shock-induced cooling in supersonic jets, the effect of rotation upon impinging jets, and vortex breakdown [Prof. Kurosaka (PI)]. Recent research in the fluids group has also demonstrated the use of strongly-pulsed fuel injection for the generation of compact, low-emissions turbulent jet flames, explored the effects of superheating on fuel droplet disruption in supersonic flow, and identified the convection and heat transfer phenomena that occur in unsteady film evaporation [Prof. Hermanson (PI)]. Technological applications include designing the mixer for the world's largest pulsed chemical laser, and the invention of the nose turret flow control of the AirBorne Laser [Prof. Breidenthal (PI)]. The results of compressor flutter, MPT noise and shaped cooling holes have long been implemented in aircraft gas turbine industry [Prof. Kurosaka (PI)]. Professor Dabiri has contributed to the highly successful and important Digital Particle Image Velocimetry (DPIV) technique and played a pivotal role in the team that pioneered the 3-component version of this technique, which allowed for full 3-D time-evolving interrogation of fluid flow fields. He has also pioneered the Digital Particle Image Thermometry and Velocimetry (DPITV) technique that allows for simultaneous temperature and velocity measurements. External collaborations involving the Fluids Group include the University of Illinois at Urbana Champagne, Michigan Technological University, Kettering University, Ecole Nationale Supérieure de Mécanique et d'Aérotechnique (ENSMA), and Kyushu Institute of Technology.

Plasma Science Group: The plasma science group has been highly successful in making major contributions to the field of innovative plasma confinement for fusion energy and to the field of computational plasma dynamics. These contributions have established UW as an international leader of innovative confinement concepts (ICC) with no other university hosting as many experiments and investigating as many concepts within a single academic department. Research in computational plasma dynamics is comprised of a synergistic combination of two concentrations: the PSI Center [DOE-funded, Prof. Jarboe (PI), Profs. Milroy and Shumlak (Co-PIs)] for developing predictability in experimental plasma devices; and the plasma dynamics group [AFOSR-funded, Prof. Shumlak (PI)] for developing numerical algorithms for advanced plasma models in a variety of applications from electric propulsion, high-power microwave devices, and space weather.

The PSI Center is a national, multi-institution center led by UW and funded by DOE. The other participants are the University of Wisconsin, Utah State University, and the Naval Research Lab. The plasma science group has been successful in securing substantial and sustained research funding, graduating many PhD students, and publishing high impact journal articles. As a result, the group is nationally and internationally recognized as a leader in the field and is viewed as a source for top-quality graduates.

Inherent in the function of the PSI Center is collaboration with experimental programs at other institutions. These collaborations include Auburn, Cal Tech, Columbia, Los Alamos National Lab, Lawrence Livermore National Lab, MIT, and Swarthmore, with the objective of providing computational development and support for experimental programs that are too small to supply

their own. The computational dynamics group also collaborates with the Air Force Research Labs at Kirtland AFB and at Edwards AFB. In addition to the scientific impact, these collaborations have broadened the impact of the research by increasing the visibility and by highlighting the need. Both of these research efforts were recently renewed in an extraordinarily competitive funding climate.

In addition to computational plasma dynamics, the plasma group is one of the world leaders in the study of fusion schemes alternative to the well-known tokamak, and it has one of the two or three largest university programs in this area. However, the new fusion energy research priorities from DOE toward tokamak-relevance, basic plasma science, and high energy density plasma physics caused the discontinuance of two experiments (TCS and ZaP), and forced the closure of our off-campus Redmond Plasma Physics Lab (RPPL). The group still has two strong experiments: the HIT Current Drive program [DOE-funded, Prof. Jarboe (PI)] on campus and the Solenoid Free Plasma Startup program [DOE-funded, Prof. Jarboe (PI)] in collaboration with, and located at, the Princeton Plasma Physics Laboratory. In response to the loss of TCS and ZaP, the plasma group has worked to secure funds for experimental research from AFOSR and NASA in addition to DOE. An advantage of the computational plasma research is its flexibility to diversify the applications towards the current trends in the field. The PSI Center is adding mainline fusion approaches to its portfolio of supported experiments. The plasma dynamics group has set the pace and direction for advanced plasma models, and as such, has a more general science mission that is still well supported.

Structures Group: Carbon fiber and composite technology is no longer the future of transportation, but the present. The Boeing 787 and programs such as the BMW Megacity vehicle are placing composites in mainstream products. The Structures Group has focused on composites safety and certification by working to understand how non-traditional composites can be implemented in aircraft or automobiles within a certification methodology. Analysis methods are developed to use in the certification process in conjunction with experimental evidence to ensure safety with a focus on understanding both static failure (strength), as well as dynamic failure (low and high velocity impact, crashworthiness, and lightning). The group has developed unique and extensive lab capabilities with industrial funding [Prof. Feraboli (PI)], particularly from Automobili Lamborghini S.p.A. Boeing and Lamborghini have been able to use the research results in the area of chopped fibers and crashworthiness. Our research in crashworthiness also directly impacts the regulations, as it is the foundation on which FAA guidance materials are built: MIL-HDBK-17, Advisory Circulars, Tech reports and FARs.

Considerable important and high-impact work has been done on multidisciplinary optimization technology for flight vehicle design focusing on the integrated aeroservoelastic aspects of the problem [Prof. Livne (PI)]. Specific contributions include the development of aeroservoelastic optimization technology for all-composite flight vehicles, including conventional and strain actuation; unsteady aerodynamic design oriented analysis (including shape sensitivity analysis) for flight vehicle shape optimization; flutter and gust response design oriented analysis for shape optimization; methods for sensitivity analysis and constraint function approximations of gust response and flutter behavior measures. Many of the concepts and methods in this area have been adopted by Boeing. The UW is internationally recognized for leadership in the area of aeroservoelastic design optimization. The work has resulted in numerous papers in international

conferences and in archival journals. In addition to Boeing and Lamborghini, Structures Group collaborations include Zona Technology, Stirling Dynamics, Inc., the University of Colorado at Boulder, the University of California at Santa Cruz, the Naval Postgraduate School, the Planetary Science Institute, and the University of Kobe.

Graduates from all of the discipline groups can be found in academia, national labs, and industry. As specific examples, Dr. Charles Greenfield is the Director of the U.S. Burning Plasma Organization (USBPO), which interfaces with the highest level of international partners for the International Thermonuclear Experimental Reactor (ITER) project. Dr. Manav Bhatia, still a post-doc at Virginia Tech, is well known for his leadership role in the area of design optimization of truss braced wing configurations. Noted entrepreneur A&A graduates include Bill Vaglienti, co-founder of Cloud Cap Technology, a leading Unmanned Systems sensor development company and Jason Andrews; founder and President and CEO of Andrews Space, Inc. Further examples of our student and alumni achievements can be seen in Appendix H.

Faculty Mentoring and Diversification

Since the department is comparatively small, responsibility for mentoring junior faculty rests with members of the related discipline group, the department chair, and the entire faculty. Senior faculty share research ideas with junior faculty and provide mentoring regarding research, teaching, and grant proposal opportunities. Junior faculty are encouraged to be aggressive and independent in building their own research programs, and that has proven successful, for example, with the development over the last six years of a world-class experimental research lab, the Automobili Lamborghini Advanced Composite Structures Laboratory (ACSL), by an ambitious and capable junior faculty member.

Diversifying the faculty ranks has been a slow process in our department. We are fortunate to have added our first female professor, who was recruited in 2002, but we have not been successful with any other under-represented group. One factor is that the very small number of qualified candidates and the intense competition for such candidates by other institutions with stronger financial capabilities. During any open faculty search, and in particular with our current search in the area of aerospace controls, female and URM applicants are actively recruited. This recruitment includes personal communication with colleagues who have students and postdocs in the job market, contacting participants in workshops specifically aimed at women and URM scientists and engineers interested in faculty careers, consulting lists of recent women PhDs in aerospace, etc. The A&A Department works with the UW's ADVANCE Center for Institutional Change, which participates in the search process by meeting with women candidates when they interview for the position, as well as helping to support the career success of female and URM faculty after they join the UW.

Section IV: Future Directions

Where the Unit is Headed

The overall goals of the UW A&A Department, as outlined in the department Strategic Plan, are to grow its education and research programs to meet industry and societal needs while

maintaining excellence in all respects. These goals include meeting the needs of the State of Washington. As specifically stated in the report of the Washington Council on Aerospace to the Governor and Legislature (attached in Appendix J), the state of Washington industry need for a workforce trained in aerospace related engineering fields is significantly larger than what the state-supported university system is currently able to produce. That report also identifies specific, aerospace-related research areas, such as Unmanned Aerial Vehicles (UAV's), composite and advanced materials and structures, the development of sustainable aviation fuels with a low carbon footprint, and aircraft design and manufacturing. The A&A Department is very well-positioned to contribute in these research areas, and plans to do so.

Subsidiary goals are to establish a recognized high level of research productivity, funding, and quality; to significantly increase national and international recognition; to further improve our leading-edge undergraduate and graduate education programs; and to achieve a leading partnership role with aerospace and other industry. We seek to hire the best available faculty candidates, to maintain an up-to-date leading edge curriculum, to continuously improve the quality of teaching, and to serve the largest possible undergraduate and graduate population within our means. In support of these goals, we intend to increase the level of funded research, as well as further increase the reach of the research beyond the more classical, traditional aerospace-related research topics.

The excellence of a program is driven, to a large extent, by the quality and commitment of its faculty and staff. We plan to press aggressively to hire top-quality new faculty, develop and exploit new opportunities for the faculty currently in the department, and work actively to do what is necessary to ensure the retention of top faculty. The size, composition and quality of the staff must be commensurate with levels of educational and research activities. As is the case with any academic department, attracting and retaining top-quality graduate and undergraduate students is also absolutely key to the success of the program. Attracting these students is, in turn, directly related to the growth, and excellence, that characterize the department's activities. We seek to increase the impact and visibility of our department's activities which requires, in part, increased interactions with government and industry and developing strategic, long-term partnerships.

Goals and opportunities

Technological changes present numerous new opportunities for aerospace research. New space technology for commercial, scientific, and military applications is growing in importance. Autonomous and semi-autonomous vehicle systems have become pervasive in military and civilian applications. Composite materials are revolutionizing aerospace structures. The decrease in fossil fuel supplies requires the development of alternative, renewable fuels for aviation. The increasing integration of flight vehicle systems, i.e., systems of systems, provides other, new research opportunities in the area of controls. The ever-increasing interaction between air, space, ground, and sea vehicle systems and the growing emphasis on human interaction with automation requires interdisciplinary methodology. Lastly, the emergence of new educational technologies and new priorities in public funding create challenges, as well as new opportunities, for higher education.

Over the next decade, advances will be required in network-enabled command, control, communications, and computing technology. Our department is already strong in theoretical and applied research that contributes to the understanding of many key controls topics. These topics include networked dynamic systems; real-time algorithms for autonomous path planning and mission management; innovative concepts for networked systems with limited sensing and communication; nonlinear geometric control of under-actuated systems; bioinspired integrated sensing, actuation, and control; numerical tools for nonlinear flight dynamics; optimization tools for the synthesis of flight control augmentation systems; and the integration of human operators in complex aerospace systems. Currently a Center of Excellence is being pursued in the area of bioinspired flight. The center's capability is being built around existing strengths in the UW A&A and Biology departments and will involve collaboration with related capabilities and military interests in the UK.

Although aerodynamics and propulsion are well-established research areas, significant challenges and new and emerging research topics exist to be explored experimentally, theoretically, and through Computational Fluid Dynamics (CFD). These topics include new aerodynamic designs and flow control approaches, wingtip vortex prediction and control, supersonic and hypersonic aerodynamics, and the aerodynamics of UAVs. Aeropropulsion research will certainly continue to focus on improved, quiet propulsion systems and ultra-low emission combustors for subsonic and supersonic aircraft. Space exploration challenges relevant to fluid mechanics may include combined rocket/air-breathing engine cycles, high-speed planetary entry vehicle aerodynamics, propulsion for planetary atmosphere flight, small-scale spacecraft thrusters, and planetary *in-situ* resource utilization. In addition to these aerospace-related topics, research programs may also be initiated in areas such as microscale fluid devices for heat transfer, biomedical applications, flow control, the fluids dynamics of underwater vehicles, geophysical fluid dynamics, and biofuels combustion.

The department has established an international reputation for leadership in innovative confinement concepts (ICCs) and computational modeling of plasmas, and expects to continue and significantly expand both experimental and computational efforts. The department has made contributions to plasma propulsion and plasma-assisted manufacturing, and is well-positioned to expand on these research projects. We are also well-positioned to move forward with a large-scale compact toroid (CT) facility. Existing ICC projects have been successful and have garnered much respect from the international community. Department faculty have the expertise and credibility to develop a large facility. Recent reorganization of the DOE Office of Fusion Energy Science identifies CT research as a focus area. The department also plans to develop further research projects in plasma propulsion. Computational projects (such as the PSI Center and the algorithm development efforts) provide essential support and complement the experimental projects. The computational algorithms and tools that are developed are applied to space plasmas, electric propulsion, and astrophysics. The computational projects have broad applicability, beyond fusion plasmas, with connections to CFD. Opportunities exist to expand these computational projects into larger, multi-institutional projects.

Future research in the area of aerospace materials, structures, and mechanics will focus on developing experimental and numerical tools to characterize the damage resistance and tolerance of composite-intensive airframes, including high-velocity or high-energy impact events such as

bird strike, hail strike, lightning strike and crashworthiness. The A&A Department already has in place demonstrated strength in these areas and plans to implement the development of physics-based predictive tools for composite material failure, targeting both traditional autoclave prepreg materials as well as new composite material forms manufactured by low-cost techniques. An additional possibility for growth can be found in the area of additive manufacturing.

In addition to the research directions and opportunities presented above, two substantial new opportunities have the potential to greatly boost the department's efforts and prospects for successfully achieving its goals to increase the size, scope, excellence, and impact of its programs. One opportunity is in the form of a potential department-naming gift arrangement with a leading aerospace company. Such a partnership will support significant growth in the department by providing additional, substantial, and permanent resources for chaired professorships, student fellowships, new equipment, and infrastructure improvements. The second opportunity is the negotiation of an agreement with an international company interested in developing aerospace capabilities and education in a foreign country. This partnership would result in a significant increase in the size and impact of our program, both domestically and abroad, including the production of additional graduates, hiring of additional faculty and support staff, acquisition of major new instrumentation, and a steady source of sponsored research that will effectively double our research footprint.

How We Will Reach Our Goals

Achieving our goals and opportunities is built around the implementation of an existing strategic plan, which is specifically focused on increasing the scope, quality, and impact of the department's research and education programs. The plan was composed in 2009 and is currently in various stages of implementation. The development of the plan was an excellent tool to pull together faculty and staff in a team effort to determine where our energy and resources are best placed in the next five to ten years. The plan provides a unified framework from which every faculty and staff member can seek opportunities for departmental enhancement. A faculty committee monitors progress quarterly and identifies further issues. Key elements of the plan are summarized below; the complete plan is available in Appendix K.

Research: Increase the number of cross-university collaborative efforts by establishing research centers that attract the participation of faculty from outside the department. Increase the annual number of proposals for MURIs, IGERTs, and center grants. Establish ongoing working relationships with NSF, DOD and other government research agency program management. Increase the level of funding from industry.

Education: Increase the production of top-quality MS and PhD graduates. Require all undergraduates to spend two quarters either in independent research or in an internship/co-op position. Update undergraduate lab equipment. Fully implement Direct Freshman Admission, and engage freshmen and sophomores actively in the A&A program. Increase the selectivity of the graduate admissions process. Strengthen the industrial and government laboratory recruitment presence within the department.

Growth: Add at least two state-funded faculty positions. Actively search to hire established, world-class faculty, including identifying and pursuing outstanding minority and women faculty candidates. Obtain sufficient fully-equipped space to support research programs, and establish a support staff sufficient to meet all program needs.

Industry: Establish executive-level relationships and contacts with Boeing, Aerojet and other appropriate companies. Establish an industry-funded affiliates program and increase the number of active industry affiliate professors. Actively identify and pursue joint UW/industry funding opportunities. Encourage industry site visits, technical interchanges, and industry visits to the department for seminars. Encourage faculty sabbaticals in industry and government. Invite industry people to serve on A&A thesis committees. Increase the number of student internships and co-ops.

Advancement: Establish a departmental Development Committee to work with the College of Engineering Office of Advancement to help cultivate donor interest in departmental programs and in donation opportunities. Host regular alumni/friends social events and present updates on the department's research, educational, and other activities, and increase the frequency of publication of our newsletter *Highflight* to twice per year.

Advancing the interests of the A&A Department and meeting the goals and challenges identified above will require changes beyond executing items listed in a strategic plan. Positive changes to the department's culture are needed as we continue to foster a spirit of academic excellence within the UW controls, fluids, structures, and plasma communities. From the standpoint of research, these changes may include maintaining and further strengthening an enriching environment that enhances student experience and creativity; and encouraging partnerships and collaborations both across and outside the UW, beyond traditional aerospace-related disciplines. It is also important to shape our research and its facilities to meet the individual research group and departmental goals, and maintain state-of-the-art experimental and computing facilities.

The A&A Department will support the State of Washington's proposed new Center for Aerospace Technology Innovation, the purpose of which will be to advance new technologies in aerospace. The envisioned Center is expected both to fund research projects at the UW as well as further encourage industry-academic partnerships.

Overall, the current level of technical support in the A&A Department is adequate, but as the department grows to meet significant new opportunities further staffing will be needed. The advising staff is currently being strained by the growth of the undergraduate and graduate programs. Most especially, the current number of fiscal staff is not adequate for their workload, which has increased, in terms of research activity, by more than 80% in the past seven years, during which time the department also suffered the loss of an experienced fiscal manager. The current level of fiscal and administrative support in the A&A department is 20% below the average for the College.

To achieve our goals in education and to maximize effectiveness in teaching also requires changes to our educational program. Such changes include establishing a graduate laboratory to be used in course instruction, for research support, and for promoting collaboration with industry

in teaching and in maintaining up-to-date course content. The latter would be facilitated by the increased participation of practicing engineers to help carry out our undergraduate and graduate teaching functions. We plan to continue our significant commitment to distance learning, and to streamline and better coordinate our graduate course offerings, including increasing use of joint-listing with other units. We are also taking steps to encourage co-ops and study abroad and to encourage faculty to make efficient use of educational technology to enhance learning, as well as increasing the mentoring of post-doctoral and graduate assistants in teaching lecture and laboratory courses. The A&A Department plans to interact with the State of Washington STEM Center, which seeks to improve K-12 student achievement and opportunity in STEM fields.

In addition to the direct benefits of the proposed department-naming gift, we would view the naming as the cornerstone of a new, substantial, long-term strategic partnership with the potential donor institution in the areas of education and research. Similarly, the international partnership under consideration would provide significant and substantial new opportunities to collaborate on research projects, and learn and teach skills demanded by international and intercultural work.

Benefits of Reaching Our Goals

The A&A Department is recognized for innovations in several important disciplines in aerospace engineering. Most notable are major advances in the fields of turbulence, plasma dynamics and fusion, space propulsion, unmanned aerial vehicles, autonomous control, hypervelocity accelerators, fluid diagnostics, gasdynamics, multi-phase flow, computational fluid mechanics, new technologies in energy conversion and thermal management, combustion, composite materials and structures, aeroelasticity, and multidisciplinary design optimization. That these new advancements have been embraced by the aerospace community points to the high quality of the research and publications generated by our faculty.

Among numerical measures of success, the average number of peer-reviewed publications per faculty member over the last three years was approximately 2.5/year. Due to the rapidly evolving pace of technology advancement in the aerospace discipline, presentation of research results at professional meetings is a primary venue for disseminating new knowledge. We note a substantial disparity of funding levels among our specialty areas, and that the faculty hired since 2001 and plasma faculty are particularly successful in attracting funding. We have good reason to expect that with opportunities to hire outstanding new faculty in emerging fields, our funding and publication productivity will increase.

The department has produced 450 new bachelor's degree graduates since 2001. Over the same period, the department graduated 317 graduate students, including 277 with master's degrees and 40 with doctorates. From 2001-2002 to the present, the undergraduate enrollment in our department has increased from 108 to 140; the graduate enrollment, from 76 to 150. The large growth in the graduate program has been, in part, due to a significant increase in the number of distance-learning students. A large fraction of our graduates (57% of the bachelor's and 43% of the master's/PhD graduates since 2001) take positions in industry, directly impacting aerospace engineering both regionally (e.g., through Boeing, Aerojet, and others) and nationally. Thirty-four percent of the bachelor's graduates continued their studies by going to graduate school.

Seventeen percent of the master's graduates chose to pursue their PhD, with smaller numbers going into the military, taking positions at research laboratories, or other government aerospace organizations (such as the FAA). The largest fraction of PhD students (43%) took industry positions; the next largest group (35%) took post-doctoral positions after graduation. Five percent of our PhD graduates accepted faculty positions immediately upon graduation.

Reaching the goals discussed in this section can reasonably be expected to have a significant impact regionally, nationally, and internationally. This impact will be realized, in part, by the substantial planned increase in the size, scope and productivity of the research program in A&A, as a result of hiring additional faculty and enrolling and graduating more students. This impact will be maximized by building on the planned increased collaboration with industry. We also expect enhanced industrial relevance due to new strategic partnerships with industry discussed in this report, which will also lead to an increased impact of our program, both locally and nationally. A significant increase in our international impact and exposure can reasonably be expected to accompany the success of the new international initiative discussed previously. The innovative work of our faculty and students, which will continue to push the boundaries of aerospace, will have benefits that will be felt not just globally, but in our case, universally!

PART B

UNIT-DEFINED QUESTIONS

1. How Our Programs Are Positioned for Changing Needs

How are our academic and research programs positioned vis-a-vis the changing needs of the aerospace industry, national interests, and the global economy?

As discussed in Section IV, there have been significant changes in the aerospace industry over the past decade. These changes can reasonably be expected to continue over the next ten years. Funding for university research is one major issue. Federal funding of aerospace research (e.g., NASA, NSF, DOE, DOD) has remained comparatively flat, and is now, in fact, undergoing reductions in many cases. At the same time, the aerospace industry continues to move, to a large extent, from being technology-driven to more economics-driven. This change has led to a focus more on near-term "factory floor" applications in research and development, and away from the more fundamental, longer-term projects that remain characteristic of university research. These situations have been exacerbated by the increasing global competition in aerospace. While the US investment in research and development has remained flat (or decreased), many other countries are significantly increasing their investment in national research and development (notable examples include South Korea, China, and Japan).

The nature of aerospace is driven by changes in the state of the art of the supporting technologies (sometimes termed technology "push") as well as trends in the environment and marketplace (market "pull"). Examples of the former include the emergence of composite structures and significant advances in communications and high-speed computing. The latter includes an ever-increasing awareness of environmental issues (such as carbon-neutral fuels, aircraft noise, and exhaust emissions) and the market forces resulting from competition. The emergence of global

terrorism has brought about changes in America's defense mission, both in terms of spending and direction that are shaping the nature of aerospace (and other) technology, research, and applications. There are also significant, ongoing evolutions in the directions of NASA's mission.

Overall, the A&A Department is well-positioned to respond to these challenges. Our Controls Group has been successful at generating and sustaining a strong and well-funded research program. The expected near-term hiring of an additional faculty member in this area will further strengthen that highly multi-disciplinary group. The Plasma Group is strong and will likely continue to do well, given the ongoing federal commitment to research in plasma confinement techniques required to sustain nuclear fusion. Composite materials will unquestionably remain a central topic for aerospace research, which bodes well for our Structures Group, although there are concerns about the amount of fundamental research support available in that area. The Fluids Group is perhaps the discipline within the department most challenged by the ongoing funding pressures. Possible strategies there include increasing the emphasis on multi-disciplinary research topics and high-speed computing (Computational Fluid Dynamics). The changing nature of aerospace may also suggest expanding our reach into areas beyond the traditional "pillars" of aerospace research to include, for example, avionics, information technology for aerospace, and human factors.

Industry increasingly is urging changes in the education of aerospace engineers. One issue is the increasing demand for new engineering talent in Washington State, a demand that is not currently being met by Washington's universities and colleges. Beyond this need, industry increasingly seeks engineering graduates who not only have a mix of fundamental skills and are capable of doing design work, but who also have an understanding of basic management, manufacturing, and large-scale systems engineering, who are familiar with the techniques of effective teaming, and who can communicate well. This increasing emphasis on the need for business-related training as part of the engineering curriculum is in addition to expectations for substantial project-based, hands-on experiences, expertise with modern computer analysis tools, all accompanied by a thorough understanding of engineering fundamentals.

Academically, we are ready to meet these challenges. Our undergraduate program contains all of the elements essential to an aerospace engineering education, including significant project components and hands-on exercises in both the junior and senior years. Our graduate degree programs are also working well and are popular with industry, as indicated by the significant increase in the enrollment of distance-learning Master's students. The PhD program is positioned for further growth as we expect to increase the size of our faculty, as well as penetrate new research areas. One issue pertaining to our PhD program is balancing the goal of the College of Engineering that we graduate a larger number of PhDs while we work in support of an industry that heavily favors the Master's degree, not the PhD, as the advanced degree that meets their needs, given that many more of our graduates seek employment in industry than at universities or in national laboratories.

In terms of capacity, there are challenges to further increasing the enrollment in our undergraduate program. The A&A Department, as is much of higher education locally, is being severely strained by the economic downturn and the budget austerity that this is forcing on the State of Washington. This situation presents a substantial fiscal challenge to expanding the size

of our program. Continuing budget pressure hinders our ability to hire new faculty, even though we are down at least two faculty members since 2000. In addition, budget cuts have resulted in the cancellation of some laboratory courses, a reduction in other course offerings, difficulties in obtaining new equipment, and threaten staff layoffs.

2. Fulfilling Our Mission with Decreased Funding

How will A&A fulfill its mission in the face of decreasing funding? How should the research and education approaches evolve, given this challenge?

The changing needs and challenges discussed above have significant implications as we move forward to fulfill, and expand, our mission in the next decade. The many positive assets of our program include its dynamic, world-recognized faculty, numerous highly-successful research programs with many notable research accomplishments, a growing body of capable and inspired undergraduate and graduate students, strong historical relationships with Boeing and other aerospace companies, an outstanding group of department alumni who have made industry-leading contributions to aerospace, and a key geographical location, being the only department in the Pacific Northwest to provide a program in aerospace engineering.

Generally speaking, we plan to move forward by building on our current strengths, while expanding into new areas and developing strategic initiatives that expand the scope and reach of the department across the university, nation and world. Expansion and strengthening of the program will involve increasing the sizes of the graduate and undergraduate classes, which in turn will require new, additional faculty in the department. Given decreasing federal funding, we will need to be aggressive in identifying and acquiring new sources of support to enable this growth. As part of this environment, the department will seek to greatly strengthen its connections with aerospace and other industry. An additional resource will be to significantly increase our interactions with state government, which has clearly stated that boosting aerospace in Washington State, given that Washington is truly a world leader in the area of aerospace, is a key state priority. The department will also move forward in the areas of research, education, and industrial interaction by continuing to implement its strategic plan.

In terms of research, the department will aggressively pursue emerging opportunities. Many of these opportunities involve extending the more traditional aerospace research areas to involve collaborations with other disciplines, for example materials science, electrical and computer engineering, biology, chemistry, applied mathematics, and others. In this sense, increasing collaboration with other academic units is not only highly desirable but is essential to growth and success. Some specific opportunities are mentioned below.

UAVs represent a key growth area for aerospace, given the emerging technologies in this area, not the least of which is the vital importance of this class of aircraft for national security. In addition to involving many core disciplines of aeronautics, including controls, aerodynamics, and propulsion, the complexities associated with the use and coordination of these vehicles involves extensive collaboration with electrical and computer engineers. Information and communication technologies also play an increasingly important role in aviation systems from the standpoint of managing ever-increasing airspace congestion.

The transition from mostly-metallic to composite structures in aerospace engineering is truly industry-changing. A&A plans to build on its existing strengths in the field of aerospace composites technology to develop and execute research programs in high-performance, state-of-the-art composite materials and structures that embrace the design, manufacture and certification issues involving these important materials.

The ever-increasing focus on environmental issues associated with aviation is certain to continue in the coming decade. In addition to new regulations on aircraft engine noise and exhaust emissions, interest is increasing in developing and using alternate fuel sources in aviation, both from the standpoint of sustainability as well as to decrease the carbon footprint associated with aircraft use. These issues will continue to create new opportunities in aerodynamics, gasdynamics, and propulsion, while at the same time pointing to increasing collaborations with chemical engineers and biologists.

The intense ongoing focus on the development of fusion energy will continue to present opportunities for the plasma group, both experimentally and computationally. The department is also well-positioned to exploit emerging opportunities in space propulsion.

Two questions that might be posed of our program are 1) whether our projected focus is more "internal" or "external," and 2) whether we plan to focus the department's energies and resources on any single, specific area. The answer to the first question is that we plan to move forward with a continued and increasing emphasis on the "external," in the form of cross-departmental or cross-institutional efforts. More extensive collaboration is required by the increasingly diverse contributions of other technical specialties to aerospace, as discussed above. At the same time, we remain fully committed to the core aerospace disciplines. Regarding the second question, the diverse, multi-faceted nature of contemporary aerospace-related research argues against strongly aligning the unit with any one specific area (for example, commercial aviation transport) when aerospace interests are, by nature, broad-spectrum (involving also, for example, military aviation, commercial and government space systems, high-speed land transportation, undersea systems, and more).

One key aspect to the expansion of the department to meet these future challenges is to thoughtfully grow the size of the faculty. The critical, near-term need for a new faculty member in the area of controls has been mentioned previously. Strengthening the department's program in structures, clearly a key area given the industry-changing development and application of composite materials and structures is another top priority. The department will also, likely in the next five years, be further challenged by the retirement of up to five senior faculty, which amounts to fully one-third of the current tenured and tenure-track faculty. It will be very important for the future impact of the department that we hire new faculty from a perspective of "repositioning," rather than simple "replacement." Even given growth, the size of the faculty may not be large enough to cover both important legacy areas and newly emerging areas of aerospace engineering. Emphasis must be placed on recruiting faculty who are outstanding aerospace experts, but also highly collaborative and willing to move in new directions throughout their careers as the nature of aerospace research, and the supporting funding structure, evolves.

In addition to moving aggressively to establish and strengthen research programs in emerging areas of aerospace research, it will be very important to the department's growth and success of its mission to significantly strengthen and expand its interactions with aerospace and other industry, both locally as well as globally. Local candidates include Boeing, and Aerojet; other major aerospace companies of interest for collaboration include Lockheed-Martin, Pratt & Whitney Rocketdyne, Northrup Grumman, General Electric, and Airbus. The A&A Department already has numerous collaborations with industry, including Insitu, Aerovel, Aeronautical Testing Services, Andrews Space, Sienna Technologies, Tethers Unlimited, and Union Oil Products.

Boeing represents both a major customer (in terms of our graduates) and a significant resource. As part of our strategic plan, we are planning on moving forward aggressively to expand and strengthen our collaborations and interactions with Boeing. Some of the approaches to be undertaken in this regard were identified in Section IV. It will be important in this effort to work closely with Boeing to identify (and, ideally, help guide) the research and development directions important to that company. These research and development initiatives would likely first build on their most directly product-oriented efforts in composites and controls, but would subsequently be expanded to include fluids/propulsion/energy topics, such as green aviation and energy harvesting. The possibility of opening a Boeing-connected laboratory or center associated with A&A will be explored. Another direction is to discuss with Boeing how Boeing facilities could be used in the execution of specific research projects of interest to both Boeing and UW. Many of these same approaches will be applied to strengthening our strategic partnership with other aerospace companies as well.

The increased collaboration with Boeing is also expected to help facilitate significant and important changes in our approaches to aerospace education. Boeing has made it clear that they are having challenges hiring sufficient numbers of engineers, especially from within Washington State. This points to the clear need for a strong connection between Boeing and A&A regarding education, as well as research. We will work to increase the involvement of Boeing engineers with our capstone design programs in both aircraft and space systems design. We plan to invite Boeing specialists to participate in departmental research and play a role on our thesis and dissertation committees, as well as encourage them to teach courses in the department. Perhaps most importantly, we need to establish an ongoing dialog with Boeing on their perceived educational needs in their new aerospace engineers, and how our program might be changed to better address those needs. One specific example is to incorporate even more "hands-on" instruction for design and making things into our undergraduate program, such as by strengthening our Design-Build-Fly and Design-Build-Launch projects. We will also consider participating in the CDIO (Conceive, Design, Implement, Operate) initiative which has the support of industry and many participating universities worldwide.

In addition to industry, we need to work much more closely with the State of Washington, which the UW and the A&A Department directly serve. The state has specifically identified aerospace as a critical area of competition for state industry and the associated workforce. A copy of this year's *Washington Council on Aerospace Report to The Governor and Legislature* is included in Appendix J of this report. The Aerospace Council recommends the creation of a Center for

Aerospace Technology Innovation specifically for the purpose of advancing new technologies relevant to aerospace. The report further states that said Center will fund projects at both UW and WSU. The UW A&A department is optimally positioned, based on education and research capabilities and goals, to play a significant part in the new Aerospace Center. Specific areas of interest listed in the report include composites and advanced materials, robotics, and aircraft design, all areas in which we and our collaborators are actively engaged.

The State of Washington is also vitally interested in expanding the engineering education capacity within the state to meet the current and future workforce needs of Washington's aerospace companies. This may (and should!) result in additional state investment to increase the engineering education capacity at both UW and WSU. Aerospace engineers in fact represent the second-largest category of aerospace-related workers in Washington State (see Appendix K), after assembly personnel. Given that we are the only unit in the state that graduates these engineers, increasing our involvement with state government on matters relating to aerospace education and training is an obvious thrust direction for our department. As discussed previously, a further increase in our undergraduate class size will bring challenges that will require additional faculty and staff, as well as additional laboratory capability. We must take these needs into account as we seek to develop and expand the size and scope of both our education and research programs.

One way to increase the capacity of our department to graduate aerospace engineers will be through the introduction of a Professional Master's Program (PMP). Such programs are normally directed at working engineers who desire to expand their training by obtaining a Master's degree. In addition to providing for increased graduate enrollment, PMPs also serve as significant sources of income for the offering department. This additional income will help with the hiring of new faculty and support staff, and other measures needed to grow the program while ensuring top quality. We have begun the process of defining and implementing a PMP.

It is also important to develop our outreach into K-12 education to increase the awareness of our program, and encourage top high school students to come to us for their professional engineering education. An additional, important goal is to work through these schools to encourage greater participation of women and underrepresented minorities, both of which groups are significant sources of new engineering talent. One particular local opportunity in this regard resides with Aviation High School, a noted aerospace-oriented program in Seattle.

APPENDIX A
ORGANIZATION CHART

DEPARTMENT OF AERONAUTICS & ASTRONAUTICS
JAMES C. HERMANSON, CHAIR

FACULTY[1] * = Listed more than once

PROFESSOR EMERITUS ..... HOFFMAN, ALAN L.
PROFESSOR EMERITUS ..... VAGNERS, JURIS
- RESEARCH/SCIENTIST ENGINEER ..... LUM, CHRISTOPHER

PROFESSOR ..... BREIDENTHAL, ROBERT E
PROFESSOR ..... BRUCKNER, ADAM P.
- RESEARCH/SCIENTIST ENGINEER ..... KNOWLEN, CARL

PROFESSOR ..... HERMANSON, JAMES C.
PROFESSOR ..... HOLSAPPLE, KEITH A
PROFESSOR ..... JARBOE, THOMAS R.

PLASMA SCIENCE INNOVATIONS (PSI) CENTER

DIRECTOR ..... JARBOE, THOMAS R. *
DEPUTY DIRECTOR ..... MILROY, RICHARD *
- ADMINISTRATIVE ASSISTANT ..... PAREJA-KLEMISCH, LUISA,

HIFI CONSULTANT
- RESEARCH SCIENTIST/ENGINEER—
  SENIOR PRINCIPAL ..... GLASSER, ALAN

BOUNDARY CONDITIONS & GEOMETRY ..... SHUMLAK, URI *
- RESEARCH SCIENTIST/ENGINEER—
  PRINCIPAL ..... MARKLIN, GEORGE J. *

TWO-FLUID TRANSPORT .... COLLEAGUES AT THE UNIVERSITY OF WISCONSIN , UTAH STATE UNIVERSITY, NAVAL RESEARCH CENTER

FLR & KINETIC EFFECTS ..... MILROY, RICHARD
- RESEARCH SCIENTIST/ENGINEER 4 ..... KIM, CHARLSON CHI SUN

INTERFACING GROUP ..... NELSON, BRIAN[2] *
- RESEARCH CONSULTANT ..... GRIFFITH, SUSAN D.
- RESEARCH SCIENTIST/ENGINEER 4 ..... KIM, CHARLSON CHI SUN *
- RESEARCH SCIENTIST/ENGINEER—
  PRINCIPAL ..... MARKLIN, GEORGE J. *

[1] Only Emeritus faculty presently active in research are listed.
[2] Brian Nelson is a Research Associate Professor in the Department of Electrical Engineering.

STEADY INDUCTIVE HELICITY INJECTED TORUS (HIT-SI)

.....NELSON, BRIAN *
• RESEARCH ASSOCIATE.....ENNIS, DAVID
• RESEARCH ASSOCIATE.....HICKS, NATHANIEL
•RESEARCH SCIENTIST/ENGINEER—
PRINCIPAL.....SMITH, ROGER J
•RESEARCH SCIENTIST/ENGINEER 4 .....FISHBURN, MATTHEW B.
•RESEARCH SCIENTIST/ENGINEER 4 .....GOLINGO, RAY
•ENGINEERING TECH LEAD .....ROGERS, JOHN
♦ENGINEERING TECH 3.....HAYWARD, JONATHAN

CHI ON NSTX

.....NELSON, BRIAN *
•RESEARCH SCIENTIST/ENGINEER—
PRINCIPAL.....RAMAN, ROGER

PROFESSOR.....KUROSAKA, MITSURU
PROFESSOR.....LIN, KUEN-YUAN
•VISITING SCIENTIST .....KIM, TAE UK
PROFESSOR.....LIVNE, ELI
PROFESSOR .....MESBAHI, MEHRAN
•RESEARCH ASSOCIATE .....DAI, RAN
PROFESSOR .....SHUMLAK, URI

RESEARCH PROFESSOR .....MILROY, RICHARD *
•RESEARCH SCIENTIST/ENGINEER
SENIOR PRINCIPAL .....STEINHAUER, LOREN

ASSOCIATE PROFESSOR EMERITUS .....MATTICK, ARTHUR T.

ASSOCIATE PROFESSOR .....DABIRI, DANA
ASSOCIATE PROFESSOR.....MORGANSEN-HILL, KRISTI A.
•RESEARCH ASSOCIATE .....TECHY, LASZLO

RESEARCH ASSOCIATE PROFESSOR .....SLOUGH, JOHN T. *

PLASMA DYNAMICS LAB

DIRECTOR .....SLOUGH, JOHN T *
•RESEARCH ASSOCIATE.....ANDREASON, SAMUEL
•ENGINEERING TECH LEAD .....PIHL, CHRISTOPHER
♦ENGINEERING TECH 1.....ARESTUN, RORM
♦ENGINEERING TECH 1.....ANDEXLER, GEORGE

ASSISTANT PROFESSOR .....FERABOLI, PAOLO
•RESEARCH SCIENTIST/ENGINEER I .....ZAMBRANA, SAM
•RESEARCH SCIENTIST/ENGINEER I .....BEAL, CHARLES

ASSISTANT PROFESSOR .....FERRANTE, ANTONINO
ASSISTANT PROFESSOR .....YOU, SETTHIVOINE

LECTURER, PART TIME.....AUSTIN, BARRIE
LECTURER, PART TIME.....KNOWLEN, CARL *
LECTURER, PART TIME.....SMITH, ROGER *

ADMINISTRATIVE STAFF

ADMINISTRATOR .....CATLETT, LYNN K.
- BUDGET FISCAL ANALYST LEAD .....ERICKSON, DAVID
- FISCAL SPECIALIST SUPERVISOR .....HALOS, CARMELA
  - ♦FISCAL SPECIALS 3 .....PARK, JENNY

ASSISTANT TO THE CHAIR .....MACZKO, KIMBERLY
COUNSELING SERVICES COORDINATOR.....ANDERSON, MARLO D
PUBLIC INFORMATION SPECIALIST .....FREDERICK, WANDA R.A.
- •COUNSELING SERVICES COORDINATOR.....GIRARD, DEIDRE

RESEARCH SCIENTIST/ENGINEER 3 (Electronics).....BLAIR, ARTHUR
RESEARCH SCIENTIST/ENGINEER 3 (Mechanical) .....GORDON, ROBERT L.

RESEARCH SCIENTIST/ENGINEER 3
(Wind Tunnel manager).....ROSS, JOHN W.
- •RESEARCH SCIENTIST/ENGINEER 2 .....BOENISH, HANS
- •RESEARCH SCIENTIST/ENGINEER 2.....PRECUP, NATHAN

SENIOR COMPUTER SPECIALIST .....BEAN, JOSHUA
SENIOR COMPUTER SPECIALIST .....LEVERSON, BRIAN R

RESEARCH SCIENTIST/ENGINEER 3 (Shop Manager) ..TRAN, DZUNG
- RESEARCH SCIENTIST/ENGINEER 3
(Instrument Maker).....PETERSON, DENNIS

ADJUNCT & AFFILIATE FACULTY

ADJUNCT PROFESSOR.....DEVASIA, SANTOSH
ADJUNCT PROFESSOR.....RHINES, PETER
ADJUNCT PROFESSOR.....RILEY, JAMES
ADJUNCT PROFESSOR.....WINGLEE, ROBERT
AFFILIATE PROFESSOR.....BAUER, PASCAL
AFFILIATE PROFESSOR.....DEN HARTOG, DANIEL
AFFILIATE PROFESSOR.....HOUSEN, KEVIN
AFFILIATE PROFESSOR.....MANI, RAMANI
AFFILIATE PROFESSOR.....RASSAIAN, MOSTAFA
AFFILIATE ASSOCIATE PROFESSOR.....CHAPPELLE, DOUG
AFFILIATE ASSOCIATE PROFESSOR.....DOUGHERTY, ROBERT

AFFILIATE ASSOCIATE PROFESSOR.....KHALIL, GAMAL
AFFILIATE ASSOCIATE PROFESSOR.....LY, UY-LOI
AFFILIATE ASSOCIATE PROFESSOR.....MOHAGHEGH, MICHAEL
AFFILIATE ASSOCIATE PROFESSOR.....MURPHY, SUSAN
AFFILIATE ASSOCIATE PROFESSOR.....NELSON, CHET
AFFILIATE ASSOCIATE PROFESSOR.....PAISLEY, DAVE
AFFILIATE ASSOCIATE PROFESSOR.....ROBERTSON, PAUL
AFFILIATE ASSOCIATE PROFESSOR.....SCHMIDT, ECKART
AFFILIATE ASSOCIATE PROFESSOR.....STICKLER, PATRICK
AFFILIATE ASSOCIATE PROFESSOR.....SWARTZ, DAVID
AFFILIATE ASSOCIATE PROFESSOR.....VAUGHAN, CHARLES
AFFILIATE ASSISTANT PROFESSOR .....MCGEER, TAD
AFFILIATE ASSISTANT PROFESSOR .....STICKLER, PATRICK
AFFILIATE ASSISTANT PROFESSOR .....ZUBE, DIETER
AFFILIATE LECTURER.....SAFARIAN, PATRICK

DECISION SUPPORT CENTER
UNIVERSITY of WASHINGTON
Finance & Facilities

Reporting Period: Biennium 2005-2007

APPENDIX B
BUDGET SUMMARY

Acco	Description	Budgeted Amount	Reporting Period	Remaining	Total Transactions
01	SALARIES AND WAGES	$10,455,536.00	$11,536,590.34	$1,153,107.91	$11,536,590.34
02	CONTRACT PERS.SERVICES	$4,050.00	$83,409.50	$15,634.62	$83,409.50
03	OTHER CONTRACTUAL SERV	$1,815,031.00	$1,292,550.97	$112,079.22	$1,292,550.97
04	TRAVEL	$384,291.00	$485,671.68	$3,788.69	$485,671.68
05	SUPPLIES AND MATERIALS	$1,039,577.00	$1,182,780.94	$35,264.51	$1,182,780.94
06	EQUIPMENT	$808,687.00	$5,832,535.53	$61,080.02	$5,832,535.53
07	RETIREMENT & BENEFITS	$1,417,714.00	$1,590,098.63	$294,885.59	$1,590,098.63
08	GRANTS & SUBSIDIES	$460,693.00	$704,094.73	$0.00	$704,094.73
17	SALARY INCREASE OFFSET	$0.00	$0.00	$0.00	$0.00
21	COST TRANSFERS	$0.00	($4,567,305.73)	$0.00	($4,567,305.73)
22	COST SHAR.(G&C ACCTG.)	$0.00	$8,114.31	$0.00	$8,114.31
25	INDIRECT COST	$3,657,042.00	$2,244,783.91	$2,736,497.46	$2,244,783.91
37	RESTR.FDS(G&C ACCTG.)	$0.00	$0.00	$15,875.00	$0.00
38	UNALLOCATD EXPEND BUDG	$1,398,167.18	$0.00	$0.00	$0.00
40	PRIOR BIEN UNEXPEN BUD	$5,980,272.53	$0.00	$0.00	$0.00
65	UNIT RESERVE ALLOCATIO	$358,740.00	$0.00	$0.00	$0.00
	TOTAL EXPENDITURES	$27,779,800.71	$20,393,324.81	$4,428,213.02	$20,393,324.81
	TOTAL DIRECT COSTS	$24,122,758.71	$18,148,540.90	$1,691,715.56	$18,148,540.90
	TOTAL FAC. & ADMIN. COSTS	$3,657,042.00	$2,244,783.91	$2,736,497.46	$2,244,783.91
	TOTAL REVENUE	$0.00	($97,604,098.36)		($106,417,698.51)

DECISION SUPPORT CENTER
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Reporting Period: Biennium 2007-2009

Account Code	Description	Budgeted Amount	Reporting Period	Remaining	Total Transactions
01	SALARIES AND WAGES	$10,272,318.00	$11,846,472.04	$896,841.67	$11,846,472.04
02	CONTRACT PERS.SERVICES	$74,900.00	$85,880.00	$18,612.50	$85,880.00
03	OTHER CONTRACTUAL SERV	$1,707,988.00	$1,536,619.96	$17,570.21	$1,536,619.96
04	TRAVEL	$466,839.00	$597,604.58	$19,628.91	$597,604.58
05	SUPPLIES AND MATERIALS	$1,471,269.00	$1,074,921.45	$67,271.59	$1,074,921.45
06	EQUIPMENT	$817,634.00	$5,455,461.52	$6,158.57	$5,455,461.52
07	RETIREMENT & BENEFITS	$1,287,810.00	$1,611,576.63	$204,350.93	$1,611,576.63
08	GRANTS & SUBSIDIES	$604,057.00	$776,918.34	$0.00	$776,918.34
21	COST TRANSFERS	$0.00	($4,549,471.12)	$0.00	($4,549,471.12)
22	COST SHAR.(G&C ACCTG.)	$0.00	$16,885.38	$0.00	$16,885.38
25	INDIRECT COST	$2,421,128.00	$2,305,926.63	$2,575,546.30	$2,305,926.63
36	ADVANCE BUDGET	$0.00	$0.00	$0.00	$0.00
37	RESTR.FDS(G&C ACCTG.)	$25,397.00	$0.00	$0.00	$0.00
38	UNALLOCATD EXPEND BUDG	$437,324.17	$0.00	$0.00	$0.00
40	PRIOR BIEN UNEXPEN BUD	$7,782,170.04	$0.00	$0.00	$0.00
65	UNIT RESERVE ALLOCATIO	($34,632.00)	$0.00	$0.00	$0.00
	TOTAL EXPENDITURES	$27,334,202.21	$20,758,795.41	$3,805,980.68	$20,758,795.41
	TOTAL DIRECT COSTS	$24,913,074.21	$18,452,868.78	$1,230,434.38	$18,452,868.78
	TOTAL FAC. & ADMIN. COSTS	$2,421,128.00	$2,305,926.63	$2,575,546.30	$2,305,926.63
	TOTAL REVENUE	$0.00	$63,012,879.14		($28,053,018.60)

DECISION SUPPORT CENTER
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Finance & Facilities

Reporting Period: Biennium 2009-2011

Account Code	Description	Budgeted Amount	Reporting Period	Remaining	Total Transactions
01	SALARIES AND WAGES	$8,612,511.00	$12,576,477.87	$372,756.74	$12,576,477.87
02	CONTRACT PERS.SERVICES	$73,798.00	$90,470.00	$1.00	$90,470.00
03	OTHER CONTRACTUAL SERV	$2,558,875.64	$1,683,820.98	$806,926.39	$1,683,820.98
04	TRAVEL	$408,047.00	$570,557.45	$0.00	$570,557.45
05	SUPPLIES AND MATERIALS	$1,593,649.14	$1,021,843.59	$1,851.00	$1,021,843.59
06	EQUIPMENT	$1,656,648.00	$5,978,492.43	$439,764.85	$5,978,492.43
07	RETIREMENT & BENEFITS	$1,711,957.00	$2,426,414.67	$92,044.86	$2,426,414.67
08	GRANTS & SUBSIDIES	$643,547.00	$965,023.91	$0.00	$965,023.91
21	COST TRANSFERS	$0.00	($4,037,988.78)	$0.00	($4,037,988.78)
22	COST SHAR.(G&C ACCTG.)	$0.00	$40,332.66	$0.00	$40,332.66
25	INDIRECT COST	$3,304,847.23	$2,965,409.76	$2,792,537.08	$2,965,409.76
36	ADVANCE BUDGET	$255,000.00	$0.00	$0.00	$0.00
37	RESTR.FDS(G&C ACCTG.)	$107,302.98	$0.00	$27,961.22	$0.00
38	UNALLOCATD EXPEND BUDG	$1,035,013.64	$0.00	$0.00	$0.00
40	PRIOR BIEN UNEXPEN BUD	$7,182,255.02	$0.00	$0.00	$0.00
	TOTAL EXPENDITURES	$29,143,451.65	$24,280,854.54	$4,533,843.14	$24,280,854.54
	TOTAL DIRECT COSTS	$25,838,604.42	$21,315,444.78	$1,741,306.06	$21,315,444.78
	TOTAL FAC. & ADMIN. COSTS	$3,304,847.23	$2,965,409.76	$2,792,537.08	$2,965,409.76
	TOTAL REVENUE	$0.00	($15,933,628.37)		($28,581,307.46)

APPENDIX C

FACULTY BY RANK

Note: Emeritus faculty are not listed

Last name	First name	Rank
BREIDENTHAL	Robert	Professor
BRUCKNER	Adam	Professor
HERMANSON	Jim	Professor
HOLSAPPLE	Keith	Professor
JARBOE	Tom	Professor
KUROSAKA	Mitsuru	Professor
LIN	Kuen	Professor
LIVNE	Eli	Professor
MESBAHI	Mehran	Professor
SHUMLAK	Uri	Professor
DABIRI	Dana	Associate Professor
MORGANSEN-HILL	Kristi	Associate Professor
FERABOLI	Paolo	Assistant Professor
FERRANTE	Antonino	Assistant Professor
YOU	Sett	Assistant Professor
SLOUGH	John	Research Associate Professor
MILROY	Richard	Research Professor

UNIVERSITY OF WASHINGTON November 2011

Name:	Robert Edward Breidenthal, Jr.
Department:	Aeronautics and Astronautics
Date of Birth:	October 9, 1951
Academic Positions:	Post-Doctoral Research Fellow, Caltech - 1978-1980 Research Assistant Professor, UW- 1980-1983 Assistant Professor, UW - 1983-1987 Associate Professor, UW - 1987-1997 Professor, UW - 1997-
Degrees:	B.S.A.E., Wichita State University, 1973 M.S., California Institute of Technology, 1974 Ph.D., California Institute of Technology, 1979
Number of Years Service on this Faculty:	31 years: August 1, 1980
Full-time Industrial:	Boeing Aerospace Company, summer 1983 Asea Brown Boveri, Switzerland, summer 1989
Consulting Work:	Boeing Aerospace Company, Flow Research, U.S. Gypsum, Arco Alaska, Rocket Research, Rocketdyne, Learjet, Peerless Mfg., Vornado, ABB, Mallen Research, TRU, Battelle, Martrawl, Homax, Metro, Engineering Ventures Northwest, Ellen Sollod Studio, Merkt Studio, Vaughan Company, CH2M Hill, Airlift Northwest, Rangehut, Cessna Aircraft, DB Western, Viper Tee, PACCAR, Ramgen, Pterofin, ClearSign Combustion.
Honors and Awards:	Sigma Gamma Tau, 1972 Tau Beta Pi, Academic Honors, Wichita State University, 1969-73 Valedictorian, 1973 Earl R. Hutton Scholarship in Aeronautical Engr., 1969-73 National Science Foundation Graduate Fellowship, 1973-76 Donald W. Douglas Graduate Fellowship in Aero. 1973-78 Outstanding Professor Award, AA Dept. 1994, 2011 Tan Chin Tuan Visiting Professor, NTU, Singapore 2005

Selected Publications:

A simple model of mixing and chemical reaction in a turbulent shear layer, J.E. Broadwell & R.E. Breidenthal 1982 *J. Fluid Mech.* **125** 397-410.

The turbulent exponential jet, R.E. Breidenthal 1986 *Phys. of Fluids* **29**(8) 2346-2347.

Laboratory experiments on the cloud-top entrainment instability, S. Shy & R.E. Breidenthal 1990 *J. Fluid Mech.* **214** 1-15.

Mixing of jets in confined volumes, R.E. Breidenthal, V.R. Buonadonna, & M.F. Weisbach 1990 *J. Fluid Mech.* **219** 531-544.

Sonic eddy - A model for compressible turbulence, R.E. Breidenthal 1992 *AIAA J.* **30**(1) 101-104, and AIAA-90-0495, Reno, Nevada, January 1990.

Flow into a black hole," D. Tordella & R.E. Breidenthal 1996 *Int. J. Modern Phys. A*, **11**(1) 161-170.

Laboratory experiments of a jet impinging on a stratified interface, A.J. Cotel, J.A. Gjestvang, N.N. Ramkhelawan & R.E. Breidenthal 1997 *Exp. Fluids* **23** 155-160.

Turbulent stratified entrainment and a new parameter for surface fluxes, R.E. Breidenthal 1999 *Recent Research Developments in Geophysical Research*, S.G. Pandalai Ed., Research Signpost, Trivandrum, India, August 1999.

Vortex persistence - A recent model for stratified entrainment and its application to geophysical flows, A.J. Cotel & R.E. Breidenthal 1999 *Geophysical Flows*, Klewer.

Non-stationary entrainment and tunneling eruptions: A dynamic template for eruption processes and magma mixing, G.W. Bergantz & R.E. Breidenthal 2001 *Geophysical Research Letters* **28** 3075-3078.

Stationary vortices and persistent turbulence in Karman grooves, G.J. Balle & R.E. Breidenthal 2002 *Journal of Turbulence* **3** 33-51.

The vortex as a clock, R.E. Breidenthal, 2003 *Advances in Fluid Mechanics*, M. Alam, R. Govindarajan, O.N. Ramesh, & K.R. Sreenivas Eds., Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India.

Elements of entrainment, R.E. Breidenthal 2006 *Turbulencia, Escola de Primavera em Transicao e Turbulencia,* ed. A.P. Silva Freire, A. Ilha, and R.E. Breidenthal, ABCM, Rio de Janeiro, **5**(2) 205-221.

The effect of acceleration on turbulent entrainment, R.E. Breidenthal 2008 *Physica Scripta T* **132** 014001.

Adam P. Bruckner

Professor, Department of Aeronautics and Astronautics
University of Washington, Seattle, WA

Education

Ph.D.: Princeton University, 1972
M.A.: Princeton University, 1968
B.Engr.: McGill University, 1966

Positions Held

Professor: Sept. 1991-present
Department Chair: July 1998-June 2010
Research Professor: July 1988 - Sept. 1991
Research Associate Professor: July 1978 – July 1988
Research Assistant Professor: July 1975 – July 1978
Research Associate: June 1972 – July 1975

Research Interests

Space systems, Mars *in situ* resource utilization, hypervelocity accelerators (ram accelerator), space propulsion and power

Selected Publications

Bruckner, A.P., and Knowlen, C., "Ram Accelerator," in *Encyclopedia of Aerospace Engineering*, Blockey, R., and Shyy, W. (eds.), John Wiley & Sons Ltd, Chichester, UK, pp. 1063-1074, 2011. (Invited)

Lee, J., Eberhardt, D.S., and **Bruckner**, A.P., "From Biplanes to Spaceplanes: The History of the University of Washington Department of Aeronautics and Astronautics," ASEE Annual Conference and Exposition, Austin, TX, June 14-17, 2009.

Knowlen, C., Higgins, A.J., Harris, P., and **Bruckner**, A.P., "Hypersonic Shock-Induced Combustion Propulsion," Paper AIAA-2009-0715, 47th Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 5-8, 2009.

Bengherbia, T., Yao, Y., Bauer, P., Knowlen, C. and **Bruckner**, A.P., "Numerical Analysis of the Thermally Choked Ram Accelerator in Sub-detonative Regime," 21st ICDERS, Poitiers, France, July 23-27, 2007.

Knowlen, C., Joseph, B. and **Bruckner**, A.P., "Ram Accelerator as an Impulsive Space Launcher: Assessment of Technical Risks," International Space Development Conference, Dallas, TX, May 25-28, 2007.

Mastrangelo, C., Borgford-Parnell, J., Renton, J., Zervas-Berg, S., **Bruckner, A.P.**, Klastorin, T., Rice, E., and Storch, R. "An Educational Concept to Compete in the Global Business Environment," Paper AIAA 2007-2230, 48th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conf., Honolulu, HI, April 23-26, 2007.

Wood, S. E., Schneider, M. A., Cardell, G., Hecht, M., Knowlen, C., **Bruckner, A. P.**, Catling, D. C., Cobos, D., and Zent, A., "Characterization and Calibration of the Phoenix TECP Relative Humidity Sensor in a Mars Atmospheric Simulation Chamber," 4th International Conference on Mars Polar Science and Exploration, Davos, Switzerland, Oct. 2-6, 2006.

Bauer, P., Knowlen, C., and **Bruckner, A.P.,** "Modeling Acceleration Effects on Ram Accelerator Thrust at High Pressure," *J. Propulsion and Power*, **21**: 955-957, 2005.

Bundy, C., Knowlen, C., and **Bruckner, A.P.**, "Unsteady Effects on Ram Accelerator Operation at Elevated Fill Pressures," *J. Propulsion and Power* **20:** 801-810, 2004.

Schneider, M.A., and **Bruckner, A.P.**, "Extraction of Water from the Martian Atmosphere," *Space Technology & Applications International Forum – STAIF-2003*, M.S. El-Genk, ed., Am. Inst. Phys. Conf. Proc. Vol. 654, pp. 1124-1132, Feb 2003.

Polkko, J., Harri, A-M., Lehto, A., Tillman, J., **Bruckner, A.P.**, and Siili T. "Digihum: Humidity Transmitter for Harsh Martian Environment, Construction and Performance Assessment," Poster PS037, XXVII General Assembly of the European Geophysicsl Society, Nice, France, April 21-26, 2002.

Bruckner, A.P., "The Ram Accelerator: A Technology Overview" Paper AIAA 2002-1014, 40th Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 14-17, 2002. (Invited)

Knowlen, C., and **Bruckner, A.P.**, "Direct Space Launch Using Ram Accelerator Technology," in *Space Technology and Applications Forum – STAIF 2001*, El-Genk, M.S., ed., Am. Inst. Phys. Conf. Proc., pp. 583-588, Feb. 2001.

Grover, M.R., Odell, E.H., Smith-Brito, S.L., Warwick, R.W., and **Bruckner, A.P.**, "Ares Explore: A Study of Human Mars Exploration Alternatives Using *In Situ* Propellant Production and Current Technology," AAS 96-332, in *The Case for Mars VI, Vol. 98, Making Mars an Affordable Destination,* McMillen, K.R., ed., AAS Science and Technology Series, Univelt, Inc., San Diego, CA, 2000, pp. 309-340 (Invited).

Schultz, E., Knowlen, C., and **Bruckner, A.P.**, "Starting Envelope of the Ram Accelerator," *J. Prop. and Power*, **16**:1040-1052, 2000.

Patents

US Patent Nos. 4,727,930 (1988); 4,938,112 (1990); 4,982,647 (1991); 5,097,743 (1992); 5,927,653 (1999)

Grants & Contracts

PI or co-PI since 1975 on numerous grants and contracts from NASA, USAF, ARO, AFOSR, ONR, NSF, USRA, Boeing, etc. Total research funding to date: ~$9,000,000.

Honors and Awards

Fellow, American Institute of Aeronautics and Astronautics (AIAA), 1997

Certificate of Appreciation, Universities Space Research Association (USRA), 1994

Professor of the Year, AA Dept. (Co-recipient) 1994

AIAA Certificate of Recognition, 1992; Certificate Appreciation, 1991

AIAA Associate Fellow, 1989

Burlington Resources, Inc. Faculty Achievement Award for Outstanding Research, 1989

USRA Distinguished Service Award, 1989

NASA Certificate of Appreciation, 1985, 1986, 1989, 1992

NASA Certificate of Recognition, 1983

AIAA Pacific Northwest Section Award for Outstanding Contribution to Aerospace Engineering, 1973

British Association Medal, McGill University, 1966

Professional Memberships

American Institute of Aeronautics and Astronautics (Fellow)

American Society of Engineering Educators

Aeroballistic Range Association

Sigma Xi

Selected Professional Service

Member, Museum of Flight Space Collections Committee, 2011-present

Member, Museum of Flight Pathfinder Award Selection Committee, 2008-present

AIAA Space Resources Technical Committee, 2007-2011

AIAA Space Colonization Technical Committee, 2003-2011

NASA/USRA RASC-AL Program Steering Committee, 2003-2008

Co-Director (founding), Global Integrated Systems Engineering (GISE) Program, University of Washington, 2006-2007

Session Co-Chair, "Space Resource Utilization on Mars," Space Technology and Applications International Forum (STAIF), 2004 -2007

Member, Local Organizing Committee, 18th International Colloquium on Dynamics of Explosions and Reactive Systems (ICDERS), Seattle, WA, July 29-August 3, 2001

AIAA Pacific Northwest Section Council Member, 1998-2000

Selected Consulting

Halotechnics, Inc., Emeryville, CA, 2011-present

USRA Space Technology Science Council, Washington, DC, 1999-2005

Kistler Aerospace Corporation, Kirkland, WA, 1994-1999

Adroit Systems, Inc., Bellevue, WA, 1998-99

U.S. Army Research Laboratory, Aberdeen, MD, 1990-96.

BIOGRAPHICAL SKETCH

James C. Hermanson
Department of Aeronautics and Astronautics
University of Washington
Seattle, WA 98195

Education

University of Washington, Seattle, WA
B.S., Aeronautics and Astronautics 1977
Graduated Magna Cum Laude

California Institute of Technology, Pasadena, CA
M.S., Aeronautics 1980

California Institute of Technology, Pasadena, CA
Ph.D., Aeronautics 1985

Universität Göttingen, Göttingen, Germany 7/85-12/85
Postdoctoral Research Fellow

Experience

University of Washington, Seattle, WA 8/02-present
Associate Professor (2002-2008), Professor (2008-), Associate Chair (2009-2010), Department Chair (2010-)

Worcester Polytechnic Institute, Worcester MA 3/95-7/02
Assistant Professor (1995-1997), Associate Professor (1997-2002), Professor (2002)

University of Connecticut Department of Mechanical Engineering, Storrs, CT 1/93-6/93
Visiting Associate Professor

United Technologies Research Center, East Hartford, CT 7/88-3/95
Research Scientist

University of Washington Applied Physics Laboratory, Seattle, WA 2/86-7/88
Senior Engineer/Research Assistant Professor

Boeing Aerospace Company, Seattle, WA 7/77-7/79
Engineer

Current Research Interests

Combustion (flame structure, flame stability, and exhaust emissions) and fluid mechanics (multi-phase flow, compressible flow, heat transfer).

Selected Honors and Awards

Best Paper Award, *18th Microgravity Science and Space Processing Symposium* (42nd AIAA Aerospace Sciences Meeting), January 2004.

Boeing Chair Professor, UW, 2002.

ASME Curriculum Innovation Award - Honorable Mention, 2001

Russell M. Searle Instructorship (*Teacher of the Year*), ME/WPI, 2001

ASME Fellow, 2000.

AIAA Associate Fellow, 1999.

George I. Alden Chair in Engineering, WPI, 1999.

Selected Publications (last ten years):

Kim, Y.J. and Hermanson, J.C., "Breakup and Vaporization of Droplets under Locally Supersonic Conditions," *Phys. Fluids*, submitted 2011.

Kim, Y.J. and Hermanson, J.C., "Disruption of Volatile and Non-volatile Droplets under Locally Supersonic Conditions," *AIAA Journal*, submitted 2011.

Kimball, J.T., Hermanson, J.C. and Allen, J.S., "Convective Structure Evolution and Heat Transfer in Quasi-Steady Evaporating Liquid Films," *Phys. Fluids*, submitted 2011.

Fregeau, M., Hermanson, J.C., Stocker, D.P., and Hegde, U.G., "Turbulent Structure Dynamics of Buoyant and Non-buoyant Pulsed Jet Diffusion Flames," *Combustion Science and Technology*, **183**, 309 – 330, 2010.

Fregeau, M. and Hermanson, J.C., "NO_x/CO Emissions of Strongly-Pulsed Jet Diffusion Flames," *Combustion Science and Technology*, **181**, 536-554, 2009.

Kimball, J.T., Bailey, M.F., and Hermanson, J.C., "Ultrasonic measurement of condensate film thickness," *Journal of the Acoustical Society of America* **124** (4), EL196-202, 2008.

Hermanson, J.C., "Dynamics of Supersonic Droplets of Volatile Liquids," *AIAA Journal*, Vol. 45 No. 3, 730-733, 2007.

Som, S.M., Kimball, J.T., Hermanson, J.C., and Allen, J.S., "Stability and Heat Transfer Analysis of Unsteady Condensing and Evaporating Films," *International Journal of Heat and Mass Transfer* Vol. 50, 1927-1937, 2007.

Chen, Z.-Q., Hermanson, J.C., Shear, M.A., and Pedersen, P.C., "Ultrasonic Monitoring of Interfacial Motion and Growth of Condensing and Non-condensing Liquid Films," *Flow Measurement and Instrumentation* **16** (6), 353-362, 2005.

Hermanson, J.C., Johari, H., Stocker, D.P., and Hegde, U.G. "Buoyancy effects in strongly-pulsed turbulent diffusion flames," *Combustion and Flame* **139**, 61-76, 2004.

Hermanson, J.C., Ghaem-Maghami, E. and Johari, H., "CO/Unburned Hydrocarbon Emissions of Strongly-Pulsed Turbulent Diffusion Flames," *Combustion Science and Technology* **176**, 1855-1866, 2004.

Tew, D.E., Waitz, I.A., and Hermanson, J.C., "Impact of Compressibility on Mixing Downstream of Lobed Mixers," *AIAA Journal* **42** (11), 2393-2396, 2004.

Hermanson, J.C., Sangras, R., Usowicz, J.E., and Johari, H., "Co-Flow Effects on Turbulent Flame Puffs," *AIAA Journal* **40** (7), 1355-1362, 2002.

Research Funding:

Research sponsored by NASA, National Science Foundation, Office of Naval Research, United Technologies Corporation, and the National Center for Microgravity Research. Research funding to date: $3,800,000.

Selected Professional Activities

Member AIAA, ASME, APS, ASEE.

Associate Editor, *AIAA Journal*, 1997-2000.

Guest Editor, *Physics of Fluids,* 2005.

Graduate Student Advising

Total number of graduate students supervised or under supervision: 29 (6 PhD, 23 MS).

Keith A. Holsapple
Professor of Aeronautics and Astronautics
University of Washington, Seattle, WA

Education

Ph.D. in A.A., (Engineering Mechanics), University of Washington, 1966
M.S. in Engineering, University of Washington, 1964
B.S. in A.E., University of Washington, 1960

Positions Held

Professor: 1982-Present
Associate Dean, College of Engineering: 1988-1997
Associate Professor: 1973-1982
Assistant Professor: 1966-1972
Predoctoral Lecturer: 1965-1966

Research Interests:

Impact Processes
Planetary Sciences
Numerical Methods
Finite Element Methods
Structures

Publications of Last 5 years: (Many of these are available at **http://adsabs.harvard.edu/physics_service.html)**

Holsapple, K. A., "On the Flow and Fluidization of Granular Materials: Applications to Large Lunar Craters, Cliff Collapses and Asteroid Shapes." 42nd Lunar and Planetary Science Conference, Contribution # 1608, 2011.

Housen, K. R., **Holsapple, K. A.,** "Momentum Transfer in Hypervelocity Collisions", 42nd Lunar and Planetary Science Conference, Contribution # 2363, 2011.

Ormö, J.; Housen, K. R.; **Holsapple, K. A.;** Lepinette, A.; Melero Asensio, I.; Torres Redondo, J., "Low-Velocity Experimental Impact Cratering Facility for the Study of Wet Target Impacts", 42nd Lunar and Planetary Science Conference, Contribution # 1608, 2011.

Housen, Kevin R.; **Holsapple, Keith A**., "Ejecta from impact craters", Icarus, 211, 1, p. 856875, 2011.

Housen, K. R.; **Holsapple, K. A.,** "Asteroids Without Ejecta", 41st Lunar and Planetary Science Conference, Contribution *No. 1533, 2010*.

Pierazzo, E.; Collins, G. S.; **Holsapple, K. A.;** Housen, K. R.; Korycansky, D. G.; Plesko, C. S.; Price, M. C.; Wünnemann, K., "Impact Hydrocode Benchmark and Validation Project: Impacts Into Cohesionless Soil", *41st Lunar and Planetary Science Conference,* LPI Contribution No. 1533, 2010.

Holsapple, Keith A., "On YORP-induced spin deformations of asteroids", *Icarus*, 205, 2, 430, 442, 2010.

Ormö, J., Lepinette, A., Sturkell, E., Lindström, M., Housen, K., **Holsapple**, K., "Dynamics of the water resurge at marine-target impact craters analyzed with a combination of low-velocity impact experiments and numerical simulation". Accepted tp appear in the Geological Society of America Special Publication "Large Meteorite Impacts IV, Feb. 2009.

Holsapple, K. A., "On the Strength of small bodies of the Solar System", *Planetary and Space Science*, 2009.

Holsapple, K. A., "The deformation of asteroids by YORP spin-up", *Lunar and Planetary Science XXXL*, March 2009.

Ormö, J., Lepinette, A., Sturkell, E., Lindström, M., Housen, K. **Holsapple**, K. "Dynamics of the water resurge at Marine-target impact craters", *Lunar and Planetary Science XXXL*, March 2009.

Holsapple, K.A. and Patrick Michel, "Tidal disruptions II: A continuum theory for solid bodies with strength, with applications to the satellites of the Solar System", *Icarus*, Volume 193, Issue 1, p. 283-30, 2008.

Holsapple, K. A., " Spinning rods, elliptical disks and solid ellipsoidal bodies: Elastic and plastic stresses and limit spins", International Journal of Non-Linear Mechanics 43, 8, 2008.

E. Pierazzo, N. Artemieva, E. Asphaug, E.C. Baldwin, J. Cazamias, R. Coker, G.S. Collins, D.A. Crawford, T. Davison, D. Elbeshausen, K.A. **Holsapple**, K.R. Housen, D.G. Korycansky, K. Wünnemann. "Validation of numerical codes for impact and explosion cratering". Meteoritics and Planetary Science 43, 12, 2008.

Holsapple, K. A., "Spin limits and spin fission of 100 km asteroids", (Abstract) *Asteroids, Comets and Meteorites, 2008,* Baltimore, July 2008.

Holsapple, K. A., "Do 100 km asteroids spin-fission into binaries?", (Abstract) *Workshop on Binary Asteroids,* Meudon, France May, 2008.

Holsapple, K. A., "Porous material models for impact studies", *Lunar and Planetary Science XXXIX paper 1391*, March 2008.

Pierazzo, E.; Artemieva, N. A.; Baldwin, E. C.; Cazamias, J.; Coker, R. F.; Collins, G. S.; Crawford, D. A.; Davison, T.; **Holsapple**, K. A.; Housen, K. R.; Korycansky, D. G.; Wünnemann, K., "The Impact Hydrocode Benchmark and Validation Project: Results of Validation Tests", (2 page paper) Lunar and Planetary Science XXXIX paper 1391, p 1177, March 2008.

Holsapple, K. A. and Kevin R. Housen, "A Crater and Its Ejecta: An Interpretation of Deep Impact", in *Deep Impact at Comet Tempel 1*, Elsevier, p. 586-597. 2007.

Holsapple, K.A. and Patrick Michel, "Tidal disruptions II: A continuum theory for solid bodies with strength, with applications to the satellites of the Solar System", *Icarus*, Volume 193, Issue 1, p. 283-30, 2007.

Holsapple, K. A., " Spin limits of Solar System bodies: From the small fast-rotators to 2003 EL61", *Icarus*, Volume 187, Issue 2, p. 500-509. 2007.

Holsapple, K. A., "On the Strength of small bodies of the Solar System", VII Workshop on Catastrophic Disruption in the Solar System (CD07), Alicante, Spain, June, 2007.

Holsapple, K. A. and Kevin R. Housen, "A Crater and Its Ejecta: An Interpretation of Deep Impact", Icarus, Volume 187, Issue 1, p. 345-356. 2007.

Pierazzo, E., N. Artemieva, E. Asphaug, J. Cazamias, R. Coker, G.S. Collins, G. Gisler, K.A. **Holsapple**, K.R. Housen, B. Ivanov, C. Johnson, D.G. Korycansky, H.J. Melosh, E.A. Taylor, E.P. Turtle, K. Wunnemann, "The Impact hydrocode Benchmark and Validation Project: Initial Results". *Lunar and Planetary Science XXXVIII paper 2015*, March 2007.

Holsapple, K. A., "Response of NEO's to Mitigation Techniques", 2007 Planetary Defense Conference, George Washington University, March, 2007 (Abstract).

Holsapple, K. A. "Formation of Binaries by Spin Fission" *Lunar and Planetary Science XXXVIII*, Paper 2440, March 2007.

Holsapple, K. A., The spin fission of small asteroids into binaries. 2007 Binary Workshop, Steamboat Springs, Co. LPSC Paper 2440.

Holsapple, K. A. and P. Michel, "Tidal Disruptions II: Solid Bodies with all Kinds of Strength" *Lunar and Planetary Science XXXVIII paper 2127*, March 2007

Michel, P. and **Holsapple**, K.A., "Collisional and tidal disruptions of small solid bodies: Influence of the internal structure and implications", Abstract, Division of Planetary Science Meeting, Pasadena, CA., Oct. 2006.

Michel, Patrick and K. A. **Holsapple**, "Tidal disturbances of small cohesionless bodies: limit planetary distances and applications" Proceedings IAU Symposium no. 236, August, 2006 Prague, Czech Republic, S236, #30.

Holsapple, K.A. and Patrick Michel, "Tidal disruptions: A continuum theory for solid bodies" *Icarus*, Volume 183, Issue 2, p. 331-348, 2006.

THOMAS RICHARD JARBOE
Professor, Aeronautics and Astronautics
Adjunct Professor of Physics, Aerospace and Energetics Research Program
Aerospace & Engineering Research Bldg. Rm.438, Box 352250
University of Washington, Seattle, WA 98195-2250; 206 685-3427
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Education and Training.

University of Illinois, Urbana, Engineering Physics B.S., 1967
University of California, Berkeley, Plasma Physics Ph.D., 1974
Honors: Member, Sigma Tau and Tau Beta Pi; Fellow, American Physical Society

Research and Professional Experience:

January 1991-present -- Professor, Aeronautics & Astronautics, Adjunct Professor of Physics, University of Washington

August 1989-December 1990 -- Professor, Nuclear Engineering, University of Washington

1974-1989 -- Los Alamos National Laboratory, NM
1985-1989 Group leader, CTR-5; 1983-1985 Deputy group leader; 1982-1983 Associate group leader; 1980-1982 Task leader; 1974-1980 Staff member; 1985-1986 Sabbatical leave, Culham Laboratory, UK

1967-1974 -- University of California, CA
1969-1974 Research Assistant; 1967-1969 Teaching Assistant
Summer 1968 Physicist, Naval Weapons Center, China Lake, CA

Publications:

Jarboe T.R.; Akcay C.; Chilenski M.A.; Ennis D.A.; Hansen C.J.; Hicks N.K.; Aboul Hosn R.Z.; Hossack A.C.; Marklin G.J.; Nelson B.A.; O'Neill R.G.; Sieck P.E.; Smith R.J.; Victor B.S.; Wrobel J.S.; Nagata M. "Recent results from the HIT-SI experiment**"** *Nuclear Fusion*, **51**(6): 2011-06-01

B. S. Victor, T. R. Jarboe, A. C. Hossack, D. A. Ennis, B. A. Nelson, R. J. Smith, C. Akcay, C. J. Hansen, G. J. Marklin, N. K. Hicks, and J. S. Wrobel "Evidence for Separatrix Formation and Sustainment with Steady Inductive Helicity Injection"Phys. *Rev. Lett.* 107, 165005 (2011) http://link.aps.org/doi/10.1103/PhysRevLett.107.165005

T R Jarboe **"**An explanation of closed-flux formation and sustainment using coaxial helicity injection on HIT-II" *PlasmaPhysics and Controlled Fusion*. **52**: (4): April 01, 2010: 045001

R. Raman, B. A. Nelson, D. Mueller, T. R. Jarboe, M. G. Bell, B. LeBlanc, R. Maqueda, J. Menard, M. Ono, M. Nagata, L. Roquemore, and V. Soukhanovskii "Solenoid-free Plasma Start-up in NSTX using Transient CHI" *J Fusion Energ* **28**:200–202 (2009)

W. T. Hamp, T. R. Jarboe, B. A. Nelson, R. G. O'Neill, R. Raman, A. J. Redd, B. T. Stewart, and D. Mueller, "Temperature and density characteristics of the Helicity Injected Torus-II spherical tokamak indicating closed flux sustainment using coaxial helicity injection", *Phys. Plasmas* **15**, 082501 (2008). http://link.aip.org/link/?PHPAEN/15/082501/1

A. J. Redd, T. R. Jarboe, W. T. Hamp, B. A. Nelson, R. G. O'Neill, and R. J. Smith "Flux Amplification in Helicity Injected Torus (HIT–II) Coaxial Helicity Injection Discharges" *Phys. Plasmas* **15**, 022506 (2008). http://link.aip.org/link/?PHPAEN/15/022506/1

R. Raman, T. R. Jarboe, D. Mueller, B. A. Nelson, M. G. Bell, M. Ono, T. Bigelow, R. Kaita, B. LeBlanc, R. Maqueda, J. Menard, S. Paul, and L. Roquemore "Plasma Startup in the National Spherical Torus Experiment Using Transient Coaxial Helicity Injection" *Phys. Plasmas*, **14**, 056106 (2007). http://link.aip.org/link/?PHPAEN/14/056106/1

R. G. O'Neill, G. J. Marklin, T. R. Jarboe, C. Akcay, W. T. Hamp, B. A. Nelson, A. J. Redd, R. J. Smith, B. T. Stewart, and J. S. Wrobel, "A Fully Relaxed Helicity Balance Model for an Inductively Driven Spheromak", *Phys. Plasmas* **14**, 112304 (2007). http://link.aip.org/link/?PHPAEN/14/112304/1

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PUBLICATIONS

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1.“Approximate Theory for the Flow Through a Cascade of Cambered Airfoils,” Ph.D. Dissertation, California Institute of Technology (University Microfilms, Ann Arbor, MI), 1968.
†2.“Spatial Oscillation Within the Boundary Layer over a Rotating Surface,” AiResearch Mfg. Co., Report No. 68-4361(1), Nov. 1968.
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Degrees

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Selected Publications

Cheung, C.H., Gray, P.G., and **Lin, K.Y.**, "Fastener as Fail-Safe Disbond/ Delamination Arrest for Laminated Composite Structures," Proc. of 18th Inter. Conf. on Composite Materials (ICCM18), Jeju Island, Korea, Aug. 21-26, 2011.

Gray, P.G., Cheung, C.H., and **Lin, K.Y.**, "Design Tool for Laminated Composite Structures Disbond Arrest Mechanism," Proc. of SAMPE 2010, Seattle, WA, May 17-20, 2010.

Cheung, C.H., Gray, P.G., and **Lin, K.Y.**, "Analysis of Fasteners as Disbond Arrest Mechanism for Laminated Composite Structures," Proc. of 51st AIAA/ASME/ASCE/ AHS/ASC Structures, Structural Dynamics, and Materials Conference, Orlando, FL, April 12-15, 2010.

Cheung, C.H., and **Lin, K.Y.**, "Reliability of Damage Tolerance Composite Structure Using Fasteners as Disbond Arrest Mechanism," Proc. of 50th AIAA/ASME/ASCE/ AHS/ASC Structures, Structural Dynamics, and Materials Conference, Palm Springs, CA, May 4-7, 2009.

Tajima, S., and **Lin, K.Y.**, "Characterization of Aging Effects in Polymeric Composites Using X-ray Photoelectron Spectroscopy," Proc. of 3rd International Symposium on Advanced Fluid/Solid Science and Technology in Experimental Mechanics, Dec. 7-10, 2008, Tainan, Taiwan (keynote paper).

Styuart, A., **Lin, K.Y.**, and Livne, E., "Probabilistic Modeling of Structural/Aeroelastic Life Cycle for Reliability Evaluation of Damage Tolerant Composite Structures," Proc. of Inter. Council of the Aeronautical Sciences (ICAS) 2008 Congress, Anchorage, Alaska, Sept. 14-19, 2008.

Styuart, A., Demasi, L., Livne, E., and **Lin, K.Y.**, "Probabilistic Modeling of Aeroelastic Life Cycle for Risk Evaluation of Composite Structures," Proc. of 10th AIAA Non-Deterministic Approaches Conf., Schaumburg, Illinois, April 7-10, 2008.

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Lin, K.Y., and Styuart, A., "Probabilistic Approach to Damage Tolerant Design of Aircraft Composite Structures," Journal of Aircraft, Vol. 44, No. 4, July 2007.

Styuart, A., and **Lin, K.Y.**, "Maintenance Planning for Aircraft Damage Tolerant Composite Structures based on Risk Assessment," Proceedings of the 9th AIAA Non-Deterministic Approaches Conference, Hawaii, April 23-26, 2007.

Richey, M., **Lin, K.Y.**, and Mohaghegh, M., "A Blended Academia-Industry Learning Model for Aircraft Composite Structures Education," Proceedings of the 48th AIAA Structures, Structural Dynamics, and Materials Conference, Hawaii, April 23-26, 2007.

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Lin, K.Y., and Styuart, A., "A Probabilistic Approach to Damage Tolerance Design of Aircraft Composite Structures," Proceedings of 47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, & Materials Conference, Newport, RI, May 1-4, 2006.

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Richey, M., **Lin, K.Y.**, and Maguire, R., "An Industrial Perspective of Composite Design and Education" Proceedings of The 6th China/Japan/US Joint Conference on Composites, Chongqing, China, June 21-23, 2004.

Taylor, D., and **Lin, K.Y.**, "Aging Effects on the Interlaminar Shear Strength of High Performance Composites," Journal of Aircraft, Volume 40, No. 5, 2003, p.971-976.

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Lin, K.Y., Rusk, D.T., and Du, J., "Equivalent Level of Safety Approach to Damage Tolerant Aircraft Structural Design," Journal of Aircraft, Vol. 39, No. 1, Jan. 2002,

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Ohno, S., **Lin, K.Y.**, Lee, and Ohuchi, F., "Surface Characterization of IM7/5260 Composites by X-ray Photoelectron Spectroscopy," Journal of Vacuum Science & Technology, Vol. 19, Issue 4, July 2001, pp. 1116-1120.

Patents

None

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Co-Director (founding), AMTAS-Advanced Materials for Transport Aircraft Structures, University of Washington, 2004- present

Session Organizer, "Structures and Education", 48th AIAA/ASME/ASCE /AHS/ASC Structures, Structural Dynamics, & Materials Conference, Hawaii, April 23-26, 2007.

Eli Livne holds B.Sc. (1974) and M.Sc. (1982) degrees in aeronautical engineering from the Technion, Israel Institute of Technology, and a Ph.D. (1990) in aerospace engineering from the University of California, Los Angeles. He also holds a high-school teaching credential in technology education from the Technion's Department of Education in Technology and Science (1974). After obtaining his undergraduate degrees he served in the Israeli Air Force in research and development roles, eventually founding its aeroelasticity / structural dynamic section. After graduating UCLA Prof. Livne joined the faculty of the Department of Aeronautics and Astronautics at the University of Washington in 1990. Over the course of his academic career, Prof. Livne has continued extensive collaboration with both industry and defense organizations. Highlights of these collaborations include structural and aeroelastic optimization and lightweight airframe design with Boeing Commercial Aircraft, membership on the NASA-Boeing High Speed Civil Transport (HSCT) Aeroelastic Concept Evaluation Team and the Boeing HSCT Aeroservoelastic working group, and contributions to industry / government wind tunnel aeroelastic tests of highly nonlinear flight vehicle configurations. Prof. Livne heads the airplane design education and research program at the University of Washington. His accomplishments have been recognized by an ASME/Boeing Structures & Materials Award (1998), NSF National Young Investigator Award, and earlier the Josephine de Karman Fellowship. With expertise in aeroelasticty, aeroservoelasticity, multidisciplinary flight vehicle optimization, aircraft design, aerospace structures, structural optimization, and structural dynamics, Professor Livne's research has been funded by NASA, the FAA, AFOSR, ONR, NSF, and by Boeing. He was an associate editor for the AIAA Journal and a guest editor for a Journal of Aircraft special section on MDO. He was one of the launch section editors for the Encyclopedia of Aerospace Engineering and has published about a hundred journal and conference papers. Currently, Prof. Livne is the Editor-in-Chief of the AIAA's (American Institute of Aeronautics and Astronautics) Journal of Aircraft.

Selected review articles and book chapters:

Livne, E., "Integrated Aeroservoelastic Optimization: Status and Progress", Journal of Aircraft, Vol. 36, No. 1, January-February 1999, pp. 122-145.

Livne, E., "Future of Airplane Aeroelasticity", Journal of Aircraft, Vol. 40, No. 6, November-December 2003, pp. 1066-1092.

Livne, E., and Weisshaar, T.A., "Aeroelasticity of Nonconventional Airplane Configurations – Past and Future", Journal of Aircraft, Vol. 40, No. 6, November-December 2003, pp. 1047-1065.

Livne, E., "The Evolution of Analytic and Computational Methods for Fixed-Wing Flight Vehicle Aeroelasticity", Volume 3, Chapter: 133:, in John Wiley's Encyclopedia of Aerospace Engineering (2010)

Mukhopadhyay , V., and Livne, E., "Aeroservoelasticity", Volume 3, Chapter 136, in John Wiley's Encyclopedia of Aerospace Engineering (2010)

Selected research articles:

Engelsen, F., and Livne, E., "Quadratic Stress Failure Constraints for Structures under Combined Steady and Random Excitation", AIAA Journal, Vol. 42, No. 1, January 2004, pp. 132-140.

Jackson, T., and Livne, E., "Integrated Aeroservoelastic Design Optimization of Actively-Controlled Strain-Actuated Flight Vehicles", Paper Number AIAA-2005-2170, 46th AIAA / ASME / ASCE / AHS / ASC Structures, Structural Dynamics, and Materials Conference, Austin, TX, April 2005.

Jackson, T., and Livne, E., "Design-Oriented Structural Model Order Reduction for Strain-Actuated Flight Vehicle Structures", AIAA Journal of Aircraft, Journal of Aircraft, vol.43, no.1, 2006, pp. 182-188.

Chen, P.C., Liu, D.D., and Livne, E., "Unsteady Aerodynamic Shape Sensitivities for Airplane Aeroservoelastic Configuration Optimization",Journal of Aircraft, vol.43, no.2, 2006, pp. 471-481.

Mor, M., and Livne, E., "Sensitivities and Approximations for Aeroservoelastic Shape Optimization with Gust Response Constraints", Journal of Aircraft, 2006, vol.43 no.5, pp. 1516-1527.

Mor, M., and Livne, E., "Shape Sensitivities Of Minimum-State Unsteady Aerodynamics Approximations using Sensitivity of Optimal Solutions to Problem Parameters", AIAA Journal, 2007, Vol. 45, No. 9, pp. 2187-2195.

Bhatia, M., and Livne, E., "Shape Sensitivities of Thermoelastic Structures with Internal and External Radiation, Part I – Steady State", AIAA Journal, 2008, Vol. 46, No. 3, pp. 578-590.

Demasi, L., and Livne, E., "Dynamic Aeroelasticity of Structurally Nonlinear Configurations Using Linear Modally Reduced Aerodynamic Generalized Forces", AIAA Journal, 2009, Vol. 47, No.1, pp. 70-90.

Demasi, L., and Livne, E., "Aeroelastic Coupling of Geometrically Nonlinear Structures and Linear Unsteady Aerodynamics: Two Formulations", Journal of Fluids and Structures, Volume 25, Issue 5, July 2009, Pages 918-935.

Bhatia, M., and Livne, E., "Design-Oriented Thermostructural Analysis with External & Internal Radiation. Part 2: Transient Response", AIAA Journal, 2009, vol. 47, May, No. 5, pp. 1228-1240.

Chen, P.C., Zhang, Z., and Livne, E., "ZEUS-DO: Design Oriented CFD-Based Unsteady Aerodynamics for Flight Vehicle Shape Optimization", AIAA-2010-2720, 51st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Orlando, Florida, Apr. 12-15, 2010

Styuart, A., Livne, E., Demasi, L., and Mor, M., "Risk Assessment of Aeroelastic Failure Phenomena in Damage Tolerant Composite Structures", AIAA Journal, Vol. 49, No. 3, March 2011, pp. 655-669.

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Areas of Expertise
Networked distributed systems, dynamic networks, control theory, optimization theory and algorithms, autonomous vehicles

Education
California State University, B.S., Engineering (Summa Cum Laude), 1989
University of Southern California, M.S., Electrical Engineering, 1991
University of Southern California, M.S., Mathematics, 1995
University of Southern California, Ph.D., Electrical Engineering, 1996

Current Position
Professor, Aeronautics and Astronautics, University of Washington, 2010 – present
Adjunct Professor, Mathematics, University of Washington, 2010 – present

Previous Appointments
(1997-1998) Lecturer, Electrical Engineering, University of Southern California
(1998-1999) Lecturer, Control and Dynamical Systems, California Institute of Technology
(1996-2000) Member of Technical Staff, Jet Propulsion Laboratory, California Institute of Technology
(2000-2002) Assistant Professor, Aerospace Engineering & Mechanics, University of Minnesota
(2002-2005) Assistant Professor, Aeronautics and Astronautics, University of Washington
(2005-2010) Associate Professor, Aeronautics and Astronautics, University of Washington

Five Representative Publications:
1. D. Zelazo and M. Mesbahi. Graph theoretic analysis and synthesis of relative sensing networks, *IEEE Transactions on Automatic Control*, 56 (5): 971-982, 2011.
2. M. Mesbahi and M. Egerstedt, *Graph Theoretic Methods in Multiagent Networks,* Princeton University Press, 2010.
3. Rahmani, M. Ji, M. Mesbahi, and M. Egerstedt. Controllability of multi-agent systems from a graph theoretic perspective, *SIAM Journal on Control and Optimization,* 48 (1): 162-186, 2009.
4. Y. Hatano, M. Mesbahi. Agreement over random networks, *IEEE Transactions on Automatic Control*, (50) 11: 1867-1872, 2005.
5. A. Das, M. Mesbahi. *Distributed* parameter estimation in sensor networks*, IEEE Conference on Sensor, Mesh, and Ad Hoc Communications and Networks*, 2006.

Five Other Publications:
1. M. Mesbahi. On state-dependent dynamic graphs and their controllability properties, *IEEE Transactions on Automatic Control*, (50) 3: 387- 392, 2005.
2. A. Das and M. Mesbahi. On K-node survivable power efficient topologies in wireless networks with sectored antennas, *IEEE International Conference on Computer Communications*, 2005.

3. J. Sandhu, M. Mesbahi, T. Tsukamaki. Cuts and flows in relative sensing and control of spatially distributed systems*, IEEE Transactions on Automatic Control* (in-press).
4. Y. Kim and M. Mesbahi. On maximizing the second smallest eigenvalue of a state-dependent graph Laplacian, *IEEE Transactions on Automatic Control*, (51) 1: 116-120, 2006.
5. Y. Kim, M. Mesbahi, F. Y. Hadaegh, Multiple-spacecraft reconfigurations through collision avoidance, bouncing, and stalemates, *Journal of Optimization Theory and its Applications*, (122) 2: 323-343, 2004.

Synergistic Activities

- NSF CAREER Award: Distributed Space Systems Control via Graph-Driven Hybrid Systems and Matrix Inequalities (PI), 2/15/2001-9/30/2007
- Has supervised ten female M.S. students to completion at the University of Washington
- Has developed the following four courses at University of Washington:
  - Optimization and Systems Sciences
  - Networked Dynamic Systems
  - Robust Control
  - Advanced Spacecraft Dynamics and Control
- Associate Editor for IEEE Transactions on Control Systems Technology

Awards and Honors

- Aeronautics and Astronautics Professor of the Year (2009, 2010)
- UW College of Engineering Innovator Award, 2008
- Aeronautics and Astronautics Professor of the Year (2004, 2005, 2006)
- University of Washington Distinguished Teaching Award, 2005
- NASA Space Act Award, 2004
- NSF CAREER Award, 2001
- Shuttle Radar Topography Mission Award, JPL, Caltech, 2000
- Achievement Award for the Cassini Program, NASA, 1998
- Cassini Attitude and Articulation Control Subsystem Award, JPL, Caltech, 1997

Collaborators (past 48 months)

M. Egerstedt (Georgia Tech), Jeff Shamma (Georgia Tech), Robert Nowak (Wisconsin), D. Grunbaum (Washington), A. Rahmani (Georgia Tech), M. Campbell (Cornell), K. Morgansen (Washington), A. Das (UW Applied Physics)

Gradudate Advisors:

Ph.D.: Prof. George Papavassilopoulos, currently at the National Technical University of Athens

Graduate students advised:

Past: Yoonsoo Kim (Ph.D. AA), A. Rahmani (Ph.D. AA), D. Zelazo (Ph.D. AA), Kunihiko Kosuge (M.S. AA), J. Sandhu (M.S. AA), A. Nguyen (M.S. AA) M. Holzinger (M.S. AA) Y. Hatano (M.S. AA), A. Matthew (M.S. AA), A. Heritier (M.S. AA), Min-Zu Tsai (M.S., 2005), Michael Frostad (M.S., 2006) Y. Shao (M.S., UMN AEM)
Current: C. Gonzalez (Ph.D. AA), A. Chapman (Ph.D. AA), M. Nabi (Ph.D. AA), U. Lee (Ph.D. AA), P. Panyakeow (Ph.D. AA), K. Hughes (M.S. AA), B. Heemstra (M.S. AA), S. Vasisht (M.S. AA)

Postdoctoral students advised:

Past: Dr. A. Das (now at Applied Physics Lab, University of Washington), D. Chakrabortty (currently at North Carolina State University, Dr. D. Zelazo (currently at the University of Stuttgart)
Current: Dr. Ran Dai

Uri Shumlak

Professor & Associate Chair, Department of Aeronautics and Astronautics
University of Washington, Seattle, WA

Degrees

Ph.D.: University of California, Berkeley, 1992
B.S.: Texas A & M University, 1987

Professional Positions

Associate Chair for Research: Nov. 2010 – present
Professor: Sep. 2007 – present
Associate Professor: Sep. 2002 – Sep. 2007
Assistant Professor: Sep. 1999 – Sep. 2002
Research Assistant Professor: Dec. 1994 – Sep. 1999
National Research Council Associate: Dec. 1992 – Dec. 1994

Research Interests

Plasma Science, Computational Plasma & Fluid Dynamics, Innovative Confinement Concepts, Fusion Energy, Advanced Space Propulsion

Honors and Awards

University of Washington College of Engineering Faculty Innovator Award 2011
American Institute of Aeronautics and Astronautics Abe Zarem Award of Excellence 2003
University of Washington Aeronautics & Astronautics Professor of the Year 2002
American Institute of Aeronautics & Astronautics Senior Member 2001
University of Washington Aeronautics & Astronautics Professor of the Year 1999
National Research Council Associateship 1992

Selected Publications

1. G.V. Vogman and U. Shumlak. Deconvolution of Stark broadened spectra for multi-point density measurements in a flow Z-pinch. *Review of Scientific Instruments* **82** (10), 0034-6748 (2011).
2. B. Srinivasan and U. Shumlak. Analytical and computational study of the ideal full two-fluid plasma model and asymptotic approximations for Hall-MHD. *Physics of Plasmas* **18** (9), 092113 (2011).
3. U. Shumlak, R. Lilly, N. Reddell, E. Sousa, and B. Srinivasan. Advanced physics calculations using a multi-fluid plasma model. *Computer Physics Communications* **182**, 1767 (2011).
4. W. Lowrie, V.S. Lukin, and U. Shumlak. *A priori* mesh quality metric error analysis applied to a high-order finite element method. *Journal of Computational Physics* **230** (14), 5564 (2011).
5. J. Loverich, A. Hakim, and U. Shumlak. A discontinuous Galerkin method for ideal two-fluid plasma equations. *Communications in Computational Physics* **9**, 240 (2011).
6. E.T. Meier, V.S. Lukin, and U. Shumlak. Spectral element spatial discretization error in solving highly anisotropic heat conduction equation. *Computer Physics Communications* **181**, 837 (2010).
7. W. Song and U. Shumlak. Ultrasonically-Aided Electrospray Source for Charged Particles Approaching Monodisperse Distributions. *Journal of Propulsion and Power* **26** (2), 353 (2010).
8. U. Shumlak, C.S. Adams, J.M. Blakely, B.-J. Chan, R. P. Golingo, S.D. Knecht, B.A. Nelson, R.J. Oberto, M.R. Sybouts, and G.V. Vogman. Equilibrium, flow shear and stability measurements in the Z-pinch. *Nuclear Fusion* **49** (7), 075039 (2009).
9. K.A. Munson, U. Shumlak, and B.A. Nelson. Extreme Ultraviolet Light Production from a ZaP Flow Z-Pinch Xenon Plasma. *Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3)* **7** (1), 013003-1-9 (2008).
10. W. Song and U. Shumlak. Charged Nanoparticle Source for High Thrust Level Colloid Thrusters. *Journal of Propulsion and Power* **24** (1), 139 (2008).
11. A. Hakim and U. Shumlak. Two-Fluid Physics and Field-Reversed Configurations. *Physics of Plasmas* **14** (5), 055911 (2007).
12. A. Hakim, J. Loverich, and U. Shumlak. A High Resolution Wave Propagation Scheme for Ideal Two-Fluid Plasma Equations. *Journal of Computational Physics* **219**,

418 (2006).

13. J. Loverich and U. Shumlak. Nonlinear full two-fluid study of *m*=0 sausage instabilities in an axisymmetric Z-pinch. *Physics of Plasmas* **13** (8), 082310 (2006).
14. M. Selwa, S.K. Solanki, K. Murawski, T.J. Wang, and U. Shumlak. Numerical Simulations of Impulsively Generated Vertical Oscillations in a Solar Coronal Arcade Loop. *Astronomy and Astrophysics* **454**, 653 (2006).
15. R.P. Golingo, U. Shumlak, and B.A. Nelson. Formation of a sheared flow Z-pinch. *Physics of Plasmas* **12** (6), 062505 (2005).
16. J. Loverich and U. Shumlak. A Discontinuous Galerkin Method for the Full Two-Fluid Plasma Model. *Computer Physics Communications* **169** (3), 251 (2005).
17. U. Shumlak, B.A. Nelson, R.P. Golingo, S.L. Jackson, E.A. Crawford, and D.J. Den Hartog. Sheared flow stabilization experiments on the ZaP flow Z-pinch. *Physics of Plasmas* **10** (4), 1683 (2003).
18. U. Shumlak and J. Loverich. Approximate Riemann Solver for the Two-Fluid Plasma Model. *Journal of Computational Physics* **187** (2), 620 (2003).
19. U. Shumlak, R.P. Golingo, B.A. Nelson, and D.J. Den Hartog. Evidence of Stabilization in the Z-Pinch. *Physical Review Letters* **87** (20), 205005 (2001).
20. U. Shumlak and T.R. Jarboe. Stable high beta spheromak equilibria using concave flux conservers. *Physics of Plasmas* **7** (7), 2959 (2000).
21. U. Shumlak and N.F. Roderick. Mitigation of the Rayleigh-Taylor instability by sheared axial flows. *Physics of Plasmas* **5** (6), 2384 (1998).
22. O.S. Jones, U. Shumlak, D.S. Eberhardt. An Implicit Scheme for Non-Ideal Magnetohydrodynamics. *Journal of Computational Physics* **130**, 231 (1997).
23. U. Shumlak and C.W. Hartman. Sheared Flow Stabilization of the *m*=1 Kink Mode in Z-Pinches. *Physical Review Letters* **75** (18), 3285 (1995).

Patents

"Plasma-Based EUV Light Source," U. Shumlak, R.P. Golingo, and B.A. Nelson, Utility Patent US 7,825,391 B2, November 2, 2010.

"Plasma-Based EUV Light Source," U. Shumlak, R.P. Golingo, and B.A. Nelson, Utility Patent US 7,372,059 B2, May 13, 2008.

Grants & Contracts

PI since 1994 on numerous grants and contracts from AFOSR, DOE, NASA, Boeing, etc. Total research funding to date: approximately $12,000,000.

Professional Memberships

American Physical Society
American Institute of Aeronautics and Astronautics
Society for Industrial and Applied Mathematics

Selected Professional Service

APS Division of Computational Physics, Conference Program Committee
APS John Dawson Award for Excellence in Plasma Physics Selection Committee, Chair
ASME Propulsion Technical Committee
DOD High Performance Computing Modernization Program Technical Evaluation Panel
NASA High Energy Space Systems Review Panel
University Fusion Association, Executive Committee Member

Selected Consulting & Expert Witness

Advanced Energy & Aerospace Programs, MSE Technology Applications, Butte, MT
Andrews Space & Technology, Seattle, WA
Boeing Company, Everett, WA
ClearSign Combustion, Seattle, WA
Computational Sciences, Huntsville, AL
OMAX Abrasive Waterjet Systems, Kent, WA

DANA DABIRI

Curriculum Vitae Highlights (Please contact me for a complete CV)

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EMPLOYMENT HISTORY

University of Washington Seattle, Washington, USA Associate Professor, Department of Aeronautics & Astronautics	9/09 – Present
University of Washington Seattle, Washington, USA Assistant Professor, Department of Aeronautics & Astronautics	1/02 – 9/09
California Institute of Technology Pasadena, CA, USA Research Scientist	4/93-12/01
General Pixels, Inc. Arcadia, CA, USA Co-founder, Developer & Marketer of PixelFlow	6/96-12/01
University of California San Diego, CA, USA Post-doctoral Research Associate Graduate Research Student	 6/92-4/93 1/88-6/92
University of California Berkeley, CA, USA Graduate Research Student	 8/85-12/87
IBM Corporation San Jose, CA, USA Co-op Mechanical Engineer	 5/86-12/86

AWARDS AND HONORS

Nominated for Distinguished Teaching Award, 2006, University of Washington
UC Regents Fellowship, 1988 – 1989, University of California, San Diego
Gallery of Fluid Motion Best Poster Award, 1993, Albuquerque, New Mexico

AFFILIATIONS AND OTHER APPOINTMENTS

Adjunct Assistant Professor, Department of Mechanical Engineering, University of Washington, 2003-present.

SELECTED PUBLICATIONS (2009-PRESENT)

Legend: 1: student, 2: institutional collaborator, 3: external collaborator, 4: post-doc, 5: scientist.

Refereed archival journal publications

1. Amin M. [1], **Dabiri D.**, Navaz H. K. [3] "Effects of secondary variables on infiltration rate of open refrigerated vertical display cases with single-band air curtain", *Applied Thermal Engineering, in press.*
2. Lei Y-C[1], Tien W-H[1], Duncan J. [1], Paul M. [1], **Dabiri D.**, Rösgen T. [3], Hove J. [3] "A vision-based hybrid particle tracking velocimetry (PTV) technique using a modified cascade-correlation peak-finding method", *Submitted to Experiments in Fluids*

3. Amin M. [1], **Dabiri D.**, Navaz H. K. [3] "A Comprehensive Experimental Study on the Effects of Geometry of Open Refrigerated Display Cases and Fluid Dynamics of Air Curtains on Infiltration Rate" *Accepted for publication in Applied Thermal Engineering*

1. Kimura F. [1], McCann J. [2], Khalil G.E. [2], **Dabiri D.**, Xia Y. [2] ,Callis J.B. [2] "Simultaneous velocity and pressure measurements using luminescent Microspheres", *Review of Scientific Instruments* **81**, 064101, 2010

2. Duncan J. [1], **Dabiri D.**, Hove J. [3], Gharib M. [3] Universal outlier detection for particle image velocimetry (PIV) & particle tracking velocimetry (PTV) data, *Meas. Sci. Technol.* **21** 057002, 2010

3. Duncan J.[1] Bryce T.,[1] Thomsen H.,[1] **Dabiri D.**, Hove J.R.[3] **"**An Extended Study of a Generalized DPIV Processing Technique**"**, *Measurement Science and Technology*, **20**, (7), 075401, 2009.

1. Susanto A.,[1] Pun C.S.,[1] **Dabiri D.** (2009) **"**Bootstrapping and DIP Test for Outlier Detection and Correction of Cross-Correlation PIV Data**"**, *submitted to Experiments in Fluids.*

4. Duncan J.,[1] Bryce T.,[1] Thomsen H.,[1] **Dabiri D.**, Hove J.R.[3] (2009) **"**An Extended Study of a Generalized DPIV Processing Technique**"**, *in revision for Measurement Science and Technology*

5. Amin M., Navaz H.K., Kehtarnavaz N., **Dabiri D.** (2009) "Systematic Approach for Solving Large-Scale Problems by Neural Network: Open Refrigerated Display Cases and Droplet Evaporation Problems", *accepted for publication in Food and Bioprocess Technology.*

6. Amin M, **Dabiri D.**, Navaz H.K. "Tracer gas technique: A new approach for steady state infiltration rate measurement of open refrigerated display cases", *Journal of Food Engineering*, **92** (2), 172-181, 2009.

7. **Dabiri D. "**Digital Liquid Crystal Particle Thermometry/Velocimetry (DLCPT/V) – A Review**"**, Invited Review Article, *Exp. Fluids*, **46** (2), 191-241, 2009.

8. Amin M. [1], Navaz H.K. [3], Kehtarnavaz N. [3], **Dabiri D.** "Systematic Approach for Solving Large-Scale Problems by Neural Network: Open Refrigerated Display Cases and Droplet Evaporation Problems", *Food and Bioprocess Technology,* 2009.

Parts of books (chapters in edited books)

1. **Dabiri D.**, "Cross-Correlation Digital Particle Image Velocimetry – A Review" in Turbulência, Ed. Freire, A.S., Iiha A., Breidenthal B., Associação Brasileira de Engenharia e Ciências Mecânicas (ABCM), 2006.

2. Gharib M.,[2] & **Dabiri D.**,[5] "An Overview of Digital Particle Image Velocimetry" in *Flow Visualization: Techniques and Examples*, Ed. Smits, A. & Lim, T. T. London, Imperial College Press, March, 2000.

3. **Dabiri D.**,[5] Zhang X.,[3] & Gharib M.,[2] "Quantitative Visualization of Three-Dimensional Free Surface Slopes and Elevations" in *Atlas of Visualization III*, Ed.: The Visualization Society of Japan, New York, CRC Press, 1997.

Patents submitted and/or awarded

1. Provisional: Record of Invention title **"Method and Apparatus for Three-Dimensional Digital Particle Image Velocimetry Using A Single Lens System,"** UW Ref#7691D, **Dabiri D.**, 2007.

2. Provisional: Record of Invention title **"Method and Apparatus for Three-Dimensional Digital Particle Image Thermometry and Velocimetry ,"** UW Ref#7690D, **Dabiri D.**, 2007

3. "**Aperture-Coded Camera System for Three Dimensional Imaging,"** Patent No. US 7,006,132 B2, Francisco P., Modarress D., Gharib M., **Dabiri D.**, Jeon D., 2006.

4. **"Aperture-Coded Camera System for Three Dimensional Imaging,"** Patent No. US 6,278,847 B1, Gharib M., **Dabiri D.**, Modares D., 2001.

Professional society memberships

- American Institute of Aeronautics and Astronautics 2002-present
- American Society of Mechanical Engineers 1992-present
- American Physical Society 1991-present
- American Society of Engineering Education 2003-present

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PROFESSIONAL PREPARATION

Harvard University, Cambridge, MA
Doctor of Philosophy, Engineering Sciences, 1999
Master of Science, Applied Mathematics, 1996
Boston University, Boston, MA,
Master of Science, Mechanical Engineering, 1994
Bachelor of Science, Mechanical Engineering (summa cum laude), 1993

EMPLOYMENT HISTORY

University of Washington, Seattle, WA
Associate Professor, Department of Aeronautics & Astronautics — 2009-present
Adjunct Associate Professor, Department of Electrical Engineering — 2009-present
Assistant Professor, Department of Aeronautics & Astronautics — 2002-2009
Adjunct Assistant Professor, Department of Electrical Engineering — 2002-2009
California Institute of Technology, Pasadena, CA
Senior Research Fellow, Control and Dynamical Systems and Mechanical Engineering — 2001-2002
Postdoctoral Scholar, Control and Dynamical Systems and Mechanical Engineering — 1999-2001
Course Lecturer, Control and Dynamical Systems — 2000
Harvard University, Cambridge, MA
Graduate Research Assistant, Division of Engineering and Applied Sciences — 1994-1999
Oak Ridge National Laboratory, Oak Ridge, TN
Graduate Research Assistant — summers 1993, 1994, 1995
Boston University, Boston, MA
Graduate Research Assistant, Aerospace and Mechanical Engineering — 1993-1994

AWARDS

O. Hugo Schuck Award for best paper in the theory category for the 2009 *American Control Conference*.
Senior Member, 2006, Institute of Electrical and Electronic Engineers.
National Science Foundation CAREER Award, 2003-2009, National Science Foundation.
Clare Boothe Luce Assistant Professor of Engineering, 2002-2007, The Luce Foundation.

JOURNAL PUBLICATIONS (PAST THREE YEARS)

1. E. Lalish and **K.A. Morgansen**, "Distributed reactive collision avoidance," *Autonomous Robots*, special issue, conditionally accepted.
2. C. Woodruff, L. Vu, **K. A. Morgansen** and D. Tomlin, "Deterministic modeling and evaluation of decision-making dynamics in sequential two-alternative forced choice tasks," *Proceedings of the IEEE, special issue on Interaction Dynamics at the Interface of Humans and Smart Machines*, accepted.
3. N. Powel and **K. A. Morgansen**, "Communication-based performance bounds in nonlinear coordinated control," *International Journal of Robust and Nonlinear Contro*l, special issue, **21**(12):1410-1420, August 2011.
4. L. Vu and **K. A. Morgansen**, "Stability of time-delay feedback switched linear systems," *IEEE Transactions on Automatic Control*, **55**(10):2385-2389, October 2010.
5. R. Pagliari, S. Kirti, **K. A. Morgansen**, T. Javidi and A. Scaglione, "A simple and scalable algorithm for alignment in broadcast networks," *IEEE Journal on Selected Areas in Communication*, **28**(7):1190-1199, September 2010.
6. B. I. Triplett, D. J. Klein and **K. A. Morgansen**, "Cooperative estimation for coordinated target tracking in a cluttered environment," *ACM/Springer Mobile Networks and Applications Journal (MONET)*, (invited—special issue), **14**(3):336-349, June 2009.
7. D. J. Klein, P. Lee, **K. A. Morgansen** and T. Javidi, "Integration of communication and control using discrete time Kuramoto models for multivehicle coordination over broadcast networks," *IEEE Journal on Selected Areas in Communication* **26**(4):695-705, May 2008.

CONFERENCE PUBLICATIONS (REFEREED, PAST THREE YEARS)

1. N. D. Powel and **K. A. Morgansen**, "Multiserver queueing for supervisory control of autonomous vehicles," *American Control Conference*, in review, 2012.
2. B. Hinson and **K. A. Morgansen**, "Flowfield estimation in the wake of a pitching and heaving airfoil," *American Control Conference*, in review, 2012.
3. L. Techy, **K. A. Morgansen** and C. Woolsey, "Long-baseline acoustic localization of the Seaglider nderwater glider," in *Proceedings of the American Control Conference*, to appear, June 2011.
4. C. Woodruff, L. Vu, **K. A. Morgansen** and D. Tomlin, "Modeling and evaluation of decision-making dynamics in sequential two-alternative forced choice tasks," in *Proceedings of the 2010 IEEE Conference on Decision and Control*, December 2010.
5. A. P. Melander, N. D. Powel, E. Lalish, **K. A. Morgansen**, J. S. Jang and J. Vian, "Implementation of deconfliction in multivehicle autonomous systems," in the 27th *International Congress of the Aeronautical Sciences*, Invited Paper, September 2010.
6. L. Techy, C. Woolsey and **K. A. Morgansen**, "Planar path following for flight vehicles in wind with turn rate and acceleration bounds," in the *IEEE International Conference on Robotics and Automation*, May 2010.
7. D. J. Klein, E. Lalish and **K. A. Morgansen**, "On controlled sinusoidal coupling," in *Proceedings of the American Control Conference*, June 2009.
8. L. Vu and **K. A. Morgansen**, "Stability of feedback switched systems with state and switching delay," in *Proceedings of the American Control Conference*, June 2009 **(recipient of the O. Hugo Schuck award for best paper in the theory category)**.
9. L. Vu and **K. A. Morgansen**, "Modeling and analysis of dynamic decision making in sequential two-choice tasks," in *Proceedings of the IEEE Conference on Decision and Control*, December 2008.
10. E. Lalish and **K. A. Morgansen**, "Decentralized reactive collision avoidance for multivehicle systems," in the *IEEE Conference on Decision and Control*, December 2008.
11. D. J. Klein and **K. A. Morgansen**, "Set stability of phase-coupled agents in discrete time," in *Proceedings of the American Control Conference*, June 2008.
12. E. Lalish, **K. A. Morgansen** and T. Tsukamaki, "Decentralized reactive collision avoidance for multiple unicycle-type vehicles," in *Proceedings of the American Control Conference*, June 2008.
13. D. J. Klein, P. K. Bettale, B. I. Triplett and **K. A. Morgansen**, "Autonomous underwater multivehicle control with limited communication: Theory and experiment," in *Proceedings of the Second IFAC Workshop on Navigation, Guidance and Control of Underwater Vehicles*, April 2008.

PROFESSIONAL SOCIETY SERVICE (PAST THREE YEARS)

Amer. Control Conf., Publications Chair (2012), *IEEE Conf. Decision and Control*, Student Activities Chair (2010), IEEE Control System Society Technical Committee on Nonlinear Control (2009-present), *Robotics Science & Systems*, Program Committee (2009, 2011), *Amer. Control Conf.*, Local Arrangements Chair (2008),

COLLABORATORS (PAST 48 MONTHS)

J. Baillieul (Boston U.), C. Belta (Boston U.), M. Betke (Boston U.), F. Bullo (UCSB), D. Castanon (Boston U.), J. D. Cohen (Princeton), T. Daniel (UW), D. Grunbaum (UW), T. Hedrick (UNCCH), P. Holmes (Princeton), T. Horiuchi (UMD), J. S. Humbert (UMD), T. Javidi (UCSD), T. Kunz (Boston U.), N. Leonard (Princeton), Y. Matsuoka (UW)I. Paschalidis (Boston U.) D. Prentice (Princeton), A. Scaglione (Cornell), J. Vagners (UW), C. Woolsey (VA Tech).

GRADUATE AND POST-GRADUATE ADVISORS AND ADVISEES:

Graduate and post-graduate advisors to Kristi A. Morgansen

Ph.D.: Prof. Roger Brockett, Harvard University;

Postgraduate: Prof. Joel Burdick, Caltech and Prof. Richard Murray, Caltech

Graduate students advised:

Past: Esther Anderson (MS AA), Patrick Bettale (MS EE), JaeDong Hwang (MS AA), Daniel J. Klein (PhD AA), Kyle Krogh (MS AA), Emmett Lalish (PhD AA), Brian Massey (MS AA), Andrew Melander (MS AA), Kudah Mushambi (MS AA), Randall Svac (MS AA), Benjamin I. Triplett (PhD AA).

Current: Atiye Alaeddini (PhD AA), Jared Becker (MS AA), Elizabeth Boardman (MS AA), Brian Hinson (PhD AA), Nathan Powel (PhD AA), Jake Quenzer (MS AA), Caleb Woodruff (PhD AA).

Postgraduate scholars advised:

Past: Dr. Christopher Lum, Dr. Anawat Pongpunwattana, Dr. Linh Vu. **Current:** Dr. Laszlo Techy.

BIOGRAPHICAL SKETCH

Paolo Feraboli
Department of Aeronautics and Astronautics
University of Washington
Seattle, WA 98195

Education

University of Bologna, Italy
B.S./ M.S. Mechanical Engineering 2002

University of California, Santa Barbara
Ph.D., Mechanical Engineering 2005

Experience

University of Washington Oct. 2009-to date
Director, Automobili Lamborghini Advanced Composite Structures Laboratory

University of Washington Sept. 2005-to date
Assistant Professor, Dept. Aeronautics & Astronautics

Boeing Commercial Airplanes June 2007-Sept. 2007
Engineering/ Scientist

NASA Langley Research Center, Hampton, VA Sept. 2004-March 2005
Visiting Researcher

Automobili Lamborghini S.p.A., Sant'Agata Bolognese, Italy Oct. 2001-July 2002
Engineer Specialist/ Composites

Current Research Interests

Composite Damage Resistance and Tolerance, composite crashworthiness, composite lightning strike behavior, airworthiness and composite certification methodology, low-cost out-of-autoclave composite material forms, integrated conceptual automotive design.

Selected Honors and Awards

1. Young Researcher Award for "Outstanding research and merit for young faculty", September 2010, American Society for Composites (ASC)
2. CMH-17 Appreciation Award, July 2009, Federal Aviation Administration/ MIL-HDBK-17
3. Hayashi Memorial International Award, June 2008, Japanese Society for Composite Materials
4. Ph.D. Research Award for "Outstanding student research", September 2004, American Society for Composites (ASC)
5. Student Award, September 2003, Automotive Division, Society of Plastics Engineers (SPE)

6. Selected Publications (last ten years):

1. P. Feraboli, B. Wade, F. Deleo, M. Rassaian, M. Higgins, A. Byar, "LS-DYNA MAT54 modeling of the axial crushing of a composite tape sinusoidal specimen", Composites (Part A), In press doi:10.1016/j.compositesa.2011.08.004
2. P. Feraboli, H. Kawakami, F. Gasco, B. Wade, L. DeOto, A. Masini, "Recyclability and reutilization of carbon fiber fabric/ epoxy composites", Journal of Composite Materials, In press doi:10.1177/0021998311420604.
3. H. Kawakami, P. Feraboli, "Lightning strike damage resistance and tolerance of patch-repaired mesh-protected carbon fiber composites", Composites (Part A), 42/9, 2011, pp. 1247-1262.
4. F. Gasco, P. Feraboli, J. Braun, J. Smith, P. Stickler, L. DeOto, "Wireless Strain Measurement for Structural Testing and Health Monitoring of carbon fiber composites", Composites (Part A), 42/9, 2011, pp. 1263-1274.
5. P. Feraboli, F. Deleo, B. Wade, M. Rassaian, M. Higgins, A. Byar, M. Reggiani, A. Bonfatti, L. DeOto, A. Masini, "Predictive modeling of an energy-absorbing sandwich structural concept using the building block approach", Composites (Part A), 41/6, 2010, pp. 774-786.
6. P. Feraboli, T. Cleveland, P. Stickler, J. Halpin, "Stochastic laminate analogy for simulating the variability in Modulus of discontinuous composite materials", Composites (Part A), 41/4, 2010, pp. 557-570.
7. P. Feraboli, H. Kawakami, "Damage of carbon/ epoxy composite plates subjected to mechanical impact and simulated lightning strike", J. of Aircraft, 47/ 3, 2010, pp. 999-1012.
8. P. Feraboli, B. Wade, F. Deleo, M. Rassaian, "Crush energy absorption of composite channel section specimens", Composites (Part A), 40/8, 2009, pp. 1248-1256.
9. P. Feraboli, "Static strength determination of laminated composite materials within the current certification methodology for aircraft structures", Journal of Aircraft, 46/4, 2009, pp. 1365-1374.
10. P. Feraboli, E. Peitso, T. Cleveland, P. Stickler, J. Halpin, "Notched behavior of prepreg-based discontinuous carbon fiber/ epoxy systems, Composites (Part A), 40/3, 2009, pp. 289-299.
11. P. Feraboli, K.T. Kedward, "A new Composite Structures Impact Performance Assessment Program", Composites Science and Technology, 66/10, 2006, pp. 1336-1347.
12. P. Feraboli, K.T. Kedward, "Enhanced evaluation of the low velocity impact response of composite plates", AIAA Journal, 42/10, 2004, pp. 2143-2152.

Research Funding:

Research sponsored by Boeing, FAA, Automobili Lamborghini, AFOSR. Research funding to date: $3,134,000.

Expenditures:

2011: $ 435,262 (to April 15th)
2010: $ 801,924
2009: $ 501,472

Graduate Student Advising

Total number of graduate students supervised or under supervision: 10 (6 MSAA/ MAE with thesis, 4 Ph.D.).

Antonino Ferrante

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http://www.aa.washington.edu/research/cfm/index.html

EDUCATION

2004 Ph.D. Mechanical and Aerospace Engineering, University of California, Irvine
1997 M.S. Aeronautics and Aerospace (with honors), von Kármán Institute for Fluid Dynamics, Belgium
1996 Laurea Ingegneria Aeronautica (summa cum laude), Università di Napoli 'Federico II', Italy

ACADEMIC POSITIONS

7/2009-Present	Assistant Professor	**University of Washington (AA)**
3/2007-6/2009	Postdoctoral Scholar	**California Institute of Technology (GALCIT)**
3/2004-2/2007	Postdoctoral Scholar	**University of California, Irvine (MAE)**
9/1998-2/2004	Graduate Research Assistant	**University of California, Irvine (MAE)**
8/1997-8/1998	Research Assistant	**Università di Napoli 'Federico II', Italy (AE)**
9/1996-6/1997	Graduate Research Assistant	**von Kármán Institute, Belgium (AA)**

HONORS AND AWARDS

2011 **National Science Foundation (NSF) CAREER Award**
Office of CyberInfrastructure, Fluid Dynamics, Particulate and Multiphase Processes

2004 **Capability Application Project on IBM Power4+**
High-Performance Computing Modernization Program, Department of Defense (HPCMP/DoD)

2003 **Gallery of Fluid Motion, Video Entry Award**
American Physical Society, Division of Fluid Dynamics

2003 **Dissertation Fellowship Award**
Henry Samueli School of Engineering, University of California, Irvine

1998 **Study Abroad Fellowship Award**
Università di Napoli 'Federico II', Italy

1997 **Belgian Government Prize & Diploma with Honors**
von Kármán Institute for Fluid Dynamics, Belgium

RESEARCH

- Multiphase turbulent flows; high-speed turbulent flows; turbulent boundary layers
- Direct Numerical Simulation (DNS) and Large-Eddy Simulation (LES) of turbulent flows
- Computational fluid dynamics (CFD) and high-performance computing (HPC)

PUBLICATIONS IN REFEREED JOURNALS

J13. Baraldi A. & **Ferrante A.**
"A mass-conserving volume of fluid method: volume tracking in incompressible isotropic turbulence"
Journal of Computational Physics, *Submitted (2011)*

J12. Lucci F., L'vov V.S., **Ferrante A.** & Elghobashi S.
"Evolution of the Lagrangian power spectrum in isotropic turbulence: DNS and analytical study"
Journal of Fluid Mechanics*, Submitted (2011)*

J11. Lucci F., **Ferrante A.** & Elghobashi S.
"Is Stokes number an appropriate indicator for turbulence modulation by particles of Taylor-length-scale size?"
Physics of Fluids*, Vol. 23, 025101, pp. 1-7 (2011)*

J10. **Ferrante A.**, Matheou G. & Dimotakis P.
" LES of an inclined sonic jet into a turbulent crossflow at Mach 3.6"
Journal of Turbulence*, Vol. 12, N. 2, pp. 1-32 (2011)*

J09. Lucci F., **Ferrante A.** & Elghobashi S.
"Modulation of isotropic turbulence by particles of Taylor-lengthscale size"
Journal of Fluid Mechanics*, Vol. 650, pp.5-55 (2010)*
Featured article in "***Focus on Fluids***" of J. Fluid Mechanics, Vol. 650, pp. 1-4 (2010)

J08. **Ferrante A.** & Elghobashi S.
"On the accuracy of the two-fluid formulation in DNS of bubble-laden turbulent boundary layers"
Physics of Fluids*, Vol.19, 045105, pp.1-8 (2007)*

J07. **Ferrante A.** & Elghobashi S.
"On the effects of microbubbles on the Taylor-Green vortex flow"
Journal of Fluid Mechanics*, Vol.572, pp.145-177 (2007)*

J06. L'vov V.S., Pomyalov A., **Ferrante A.** & Elghobashi S.
"An analytical model for temporally-developing turbulent boundary layers"
***Journal of Experimental and Theoretical Physics Letters**, Vol. 86, pp.102-107 (2007)*

J05. **Ferrante A.** & Elghobashi S.
"Reynolds number effect on drag reduction in a microbubble-laden spatially developing turbulent boundary layer"
***Journal of Fluid Mechanics**, Vol.543, pp.93-106 (2005)*

J04. **Ferrante A.**, Elghobashi S., Adams P., Valenciano M., Longmire D.
"Evolution of Quasi-Streamwise Vortex Tubes and Wall-Streaks in a Bubble-Laden Turbulent Boundary Layer over a Flat Plate"
***Physics of Fluids**, Vol.16, n.9, S2 (2004)*

J03. **Ferrante A.** & Elghobashi S.
"On the physical mechanisms of drag reduction in a spatially developing turbulent boundary layer laden with microbubbles"
***Journal of Fluid Mechanics**, Vol.503, pp.345-355 (2004)*

J02. **Ferrante A.** & Elghobashi S.
"A robust method for generating inflow conditions for direct simulations of spatially developing turbulent boundary layers"
***Journal of Computational Physics**, Vol.198, pp.372-387 (2004)*

J01. **Ferrante A.** & Elghobashi S.
"On the physical mechanisms of two-way coupling in particle-laden isotropic turbulence"
***Physics of Fluids**, Vol.15, n.2, pp.315-329 (2003)*

ARCHIVAL CONFERENCE PAPERS

CP07. **Ferrante A.** & Baraldi A.
"A mass-conserving volume of fluid method: volume tracking in incompressible isotropic turbulence"
20th AIAA Computational Fluid Dynamics Conference
Honolulu, Hawaii, June 27-30, 2011

CP06. Lucci F., **Ferrante A.** & Elghobashi S.
"Turbulence modulation by particles of the Taylor-lengthscale size: is Stokes number an appropriate indicator?" ***7th International Conference on Multiphase Flow (ICMF 2010)***
Tampa, Florida, May 30 - June 4, 2010

CP05. **Ferrante A.**, Matheou G. & Dimotakis P.E.
"LES of an inclined jet into a supersonic turbulent crossflow: synthetic inflow conditions"
48th AIAA Aerospace Science Meeting, AIAA Paper 2010-1287
Orlando, Florida, January 4-7, 2010

CP04. **Ferrante A.**, Pantano C., Matheou G. & Dimotakis P.E.
"On the effects of the upstream conditions on the transition of an inclined jet into a supersonic cross-flow"
47th AIAA Aerospace Science Meeting, AIAA Paper 2009-1511
Orlando, Florida, January 5-8, 2009

CP03. **Ferrante A.** & Elghobashi S.
"On the effects of finite-size particles on decaying isotropic turbulence"
International Conference on Multiphase Flow
Leipzig, Germany, July 9-13, 2007

CP02. **Ferrante A.** & Elghobashi S.
"Drag reduction in a microbubble-laden turbulent boundary layer: DNS using the two-fluid approach"
26th Symposium on Naval Hydrodynamics
Rome, Italy, September 17-22, 2006

CP01. **Ferrante A.** & Elghobashi S.
"Reynolds number effects on drag reduction in a bubble-laden spatially developing turbulent boundary layer over a flat plate"
2nd International Symposium on Seawater Drag Reduction (ISSDR)
Busan, Korea, May 23-26, 2005

TEACHING

AA543 – Computational Fluid Dynamics (Winter 2010/2011); **AA544** – Turbulence Modeling & Simulation (Spring 2010/2011); **AA402 –** Fluid Mechanics (Fall 2010/2011)

PROFESSIONAL ACTIVITIES & SERVICES

a) Reviewer for premiere journals; b) Chaired APS-DFD and AIAA Aerospace Science Meeting sessions
c) Cyber Fluid Dynamics: DNS Database *http://cfmdatabase.aa.washington.edu/*
d) Member of the Graduate Student and Computer Committees in Aeronautics & Astronautics at the UW
e) Professional memberships: American Physical Society (APS), American Institute of Aeronautics & Astronautics (AIAA), Institute of Electrical and Electronics Engineers (IEEE)

Setthivoine You

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EDUCATION

Ph.D., Physics, Imperial College, London, UK (2002)
M.Sci., Physics, Imperial College, London, UK (1997)
Baccalauréat C, Option Internationale, Lycée International, St-Germain-en-Laye, France (1993)

RESEARCH

Fusion energy, advanced space propulsion, astrophysical jets. Plasma physics of magnetic confinement concepts envisioned for compact fusion power. Physics and development of plasma thrusters. Cellular automata and lattice Boltzmann numerical approach to plasma dynamics. Density limits and refuelling in tokamaks.

EMPLOYMENT

Assistant Professor – Dept. of Aeronautics and Astronautics, University of Washington, Seattle, USA
2009 Sep – present

JSPS Postdoctoral Fellow – Dept. of Electrical Engineering, University of Tokyo, Japan
2007 Nov – 2009 Jul

Foreign Researcher – High Temperature Plasma Center, University of Tokyo, Japan
2007 Jan – Nov

Postdoctoral Scholar – Dept. of Applied Physics, California Institute of Technology, Pasadena, California, USA
2002 Sep –2006 Sep

Scientific Programmer – Confinement & Fuelling Group, UKAEA Fusion, Culham Science Centre, Culham, UK
2002 Mar – Sep

Doctoral Candidate – Confinement & Fuelling Group, UKAEA Fusion, Culham Science Centre, Culham, UK
1997 Sep – 2002 Mar

TEACHING

Instructor – University of Washington (2009 – present)
Undergraduate**:** Engineering Thermodynamics, Aerospace Heat Transfer
Graduate**:** Plasma Cross-field Transport, Fusion Energy for Space Power and Propulsion

Tutor – University of Tokyo (2008)
Graduate: Fundamentals of Plasma Physics

Co-mentor, Summer Undergraduate Research Fellowship (SURF) students – Caltech (2005 – 2006)
Retarding grid particle energy analyzer, prototype of resistive bolometer

Instructor and organizer – UKAEA Fusion (2000 – 2001)
Graduate: Introduction to tokamak physics (seminar)

PROFESSIONAL SERVICE

Review panel member, NASA ROSES Solar and Heliospheric Review Panel, Washington DC (2011)
Consultant, General Fusion, Vancouver, Canada (2011)
Graduate Committee member, Aeronautics & Astronautics, University of Washington (present)
Sigma Gamma Tau faculty advisor, University of Washington Chapter (2010 – present)
Qualifying Exam Committee (Chair), Aeronautics & Astronautics, University of Washington (2011)
General Doctoral Exam Committee (GSR), Physics, University of Washington (2011)
Mubadala/UAEU/UW Planning Committee member, University of Washington (2010-2011)
Reviewer, ARRA proposals, US Dept. of Energy, Office of Fusion Energy Sciences (2009)
Reviewer, RRF proposals, Royalty Research Fund, University of Washington (2009, 2010)

PUBLIC SERVICE

Lecture on "Astrophysical Jets and Plasma Physics", MENSA Science Special Inter. Group, Redmond, Wash., USA (2011)
Presentations on "The Solar System", Lycée franco-japonais (high school), Tokyo, Japan (2008 - 2009)
Judge, Science Fair, AGBU Manoogian-Demirdjian school, Canoga Park, California, USA (2005 - 2006)
Television documentary participant, National Geographic Channel "The Death of the Sun" (2005)
Demonstration of wave physics, public outreach event "Discover Plasmas", Denver, Colorado, USA (2005)
Committee member, astronomy society, science-fiction society, Imperial College (1994 – 1996)

AWARDS

Foreign postdoctoral fellowship and research grant – Japan Society for the Promotion of Science (JSPS) (2007-2009)
Research graduate studentship – UK Dept. of Trade & Industry/Eng. Phys. Sci. Res. Council (1997-2001)
Research summer studentship – Internat. Assoc. for the Exchange of Students for Techn. Experience (IAESTE) (1997)

DISTINCTIONS

Cover of Physical Review Letters, Vol. 95, 4 (2005)
1st prize, student presentation, 27th Institute of Physics conference, Pitlochry, Scotland (1999)
Associate of the Royal College of Science (1997)
1st prize, final year project, Imperial College (1997)

PUBLICATIONS

Refereed journals (17), Conference abstracts (24), Talks (7), Ph.D. dissertation

APPENDIX D

EXISTING PROGRAM REVIEW: HEC BOARD SUMMARY

Name of unit	Department of Aeronautics & Astronautics
Name of school/college	College of Engineering
Degree title(s)	BSAAE, MSAA, MSAE, PhD
Year of last review	2001
Current date	November 1, 2011

A. Documentation of continuing need, including reference to the statewide and regional needs assessment (you may cut and paste from Part A, Section IV, above).

A description of our ABET-accredited undergraduate BSAAE degree can be found on our website: http://www.aa.washington.edu/admissions/undergrad.html, and the undergraduate curriculum is shown in the UW course catalog: http://www.washington.edu/students/crscat/aa.html. The State of Washington has specifically identified aerospace as a critical area of competition for state industry. The need for a workforce trained in aerospace related engineering fields is significantly larger than what the state-supported university system is currently able to produce. A copy of this year's *Washington Council on Aerospace Report to The Governor and Legislature* is included in Appendix K of this report, which highlights worker training in aerospace as a key issue for the State. The Aerospace Council also recommends the creation of a Center for Aerospace Technology Innovation specifically for the purpose of advancing new technologies relevant to aerospace and further states that said Center will fund projects at both UW and WSU. The UW A&A department is optimally positioned, based on education and research capabilities and goals, to play a significant part in the new Aerospace Center. Specific areas of interest listed in the state report include composites and advanced materials, robotics, and aircraft design, all areas in which we and our collaborators are actively engaged.

B. Assessment information related to expected student learning outcomes and the achievement of the program's objectives (you may cut and paste from Part A, Section II, above).

The goals and objectives of the undergraduate program are to provide a challenging and comprehensive education, a solid foundation in the engineering sciences related to aerospace engineering, and a strong systems perspective; to develop engineering creativity through design experience and the necessary functional skills and understanding of the societal context in which engineering is practiced; and to prepare graduates to succeed in engineering careers and to instill lifelong learning. The expected outcomes for graduates are that they will be skilled in engineering fundamentals, engineering design, laboratory skills, synthesis of various engineering disciplines, and working in a team environment. Graduates are expected to be highly regarded by employers in aeronautics, astronautics, energy systems, and related fields. They will develop strong interpersonal skills and a desire for life-long learning that will help them succeed in their chosen careers. Graduates will be valued at local, national, and international industries, as well as at government organizations and institutions of higher learning.

The goals and outcomes for our graduate students build on those for our undergraduates, with the additional expectation that their specific graduate degrees will give them a more in-depth and advanced academic view of the concepts of aeronautical and astronautical engineering, and, for MSAA degrees with theses, a significant research component. PhD graduates conduct in-depth scientific research leading to substantial and original research contributions. The outcomes of each specific graduate degree program are:

- MAE graduates will emerge from the program with the practical engineering skills needed in industry and the essential project management skills to advance professionally.
- MAE-CMS graduates will have gained the practical engineering and project management skills necessary to become leaders in the growing field of composite materials, as applied to the commercial airline industry.
- MSAA graduates will have in-depth knowledge in their specific area of interest and will be able to pursue advanced degrees, or careers in industry, government, or the engineering sciences.
- PhD graduates will be able to pursue leadership roles in academia, industry, and at top engineering research institutions.

The undergraduate and graduate programs use a variety of similar methods to evaluate student learning (see Table 1 below). On a quarterly basis, the grades of each student are assessed and compared with course averages, while noting trends, variances, and consistencies from year to year and in comparison with other courses in the department. Other methods of evaluating graduate student learning in the department include tracking awards and external recognition, publications, conference presentations, and progress in taking milestone exams (for PhD students). In undergraduate classes, new instructors also evaluate student learning through weekly pop quizzes which assess if the students are learning what the instructor expects them to learn. The table below notes which methods are used to assess student learning in each specific degree.

Table 1. Methods of evaluation of student learning

	Course evals	**CIDR feedback & evals**	**Exams***	**Course grades**	**Publications**	**Conference presentations**	**Awards & external recognition**	**Entrance & exit interviews & surveys**
BSAAE	✔	✔	✔	✔			✔	✔
MAE	✔		✔	✔			✔	
MAE-CMS	✔		✔	✔			✔	
MSAA	✔		✔	✔	✔	✔	✔	
PhD	✔		✔	✔	✔	✔	✔	

*For PhD candidates, exams include qualifying and general exams, and defense of dissertation.

C. Plans to improve the quality and productivity of the program (you may cut and paste from Part A, Section IV, above).

The findings gleaned from our surveys of undergraduate students and alumni have led to a variety of curricular changes in our undergraduate program, which are listed in Appendix F. Furthermore, as mentioned above, the undergraduate program is undergoing review this year and some restructuring is expected.

The outcomes of the graduate program assessments mentioned above have led to an almost complete revamping of the graduate curriculum over the last five years (see Appendix F Course Changes). Many of these changes resulted in course content that was more comprehensive and state-of-the-art to prepare students for research and work in industry. Another outcome was the creation and funding of A&A graduate student organizations, such as the Graduate Student Social Committee and the A&A Graduate Student Organization (both UW-registered groups). These groups plan events to encourage graduate/faculty mentoring and camaraderie. The events, attended by graduates, faculty and staff, have resulted in greater collegiality among these groups.

Number of instructional faculty, students enrolled, and degrees granted over last three years (Autumn-Summer)

	2008-2009	2009-2010	2010-2011
FTE instructional faculty	16.26	16.0	16.23
FTE graduate teaching assistants	6.12	3.73	5.23
Degree Program: BSAAE			
Headcount of enrolled students	112	116	116
Number of degrees granted	39	51	39
Degree Program: MSAA			
Headcount of enrolled students	62	65	66
Number of degrees granted	26	26	20
Degree Program: MSAE (includes MSAE-CMS)			
Headcount of enrolled students	25	24	26
Number of degrees granted	6	7	4
Degree Program: PhD			
Headcount of enrolled students	37	35	39
Number of degrees granted	3	6	4

NOTE: "Headcount of enrolled students" (undergraduate) = number of declared majors as of 10th day of Autumn Quarter.

APPENDIX E
ENROLLMENT AND GRADUATION STATISTICS

Enrollment during the 1980s was at capacity levels for that time, with 120-140 undergraduates and 120-140 graduate students, with many qualified students turned away. Those levels dropped considerably by the mid-1990s, as a result of the recession the aerospace industry experienced at the end of the cold war. Enrollment in the undergraduate program began to recover in the late 1990s, and enrollment in the graduate programs stabilized in 2000, with significant growth in recent years. Enrollment and graduation statistics over the past 10 years for each of the programs in A&A are presented in Appendix E (figure numbers cited below refer to this Appendix).

The undergraduate population was roughly constant between 2000 and 2007 (Fig. E-1). Since 2008 enrollment has steadily increased, and in 2011 it is now approximately 29% higher than the 2000-2007 average. Historically, the BSAAE degree program has been an upper-division only (i.e., junior and senior) program. Beginning in the late 1990s, the department began a process of inviting high-achieving lower-division students to join the department at the start of their sophomore year as Early Admission students,. The number of Early Admits entering the department increased significantly in 2006, as seen in Fig. E-2, but has been roughly constant since that time. Currently, about 25% of students in the junior class are ones who were originally admitted through Early Admission. Some increase in undergraduate enrollment is due to an experimental admission process, called Advanced Admission, which was initiated by the College of Engineering in 2008 but discontinued in 2011. This process allowed selected students to enter an engineering program of their choice at the end of their freshman year. Further, 2011 is the first year of Direct Freshman Admissions in our department, a process which admits a limited number of freshmen to the department at the start of their freshman year. These various admission data are summarized in Fig. E-2.

The graduate program in the A&A department has significantly increased in size over the past ten years, from 76 students in 2000-2001 to 131 in 2010-2011, as can be seen in Fig. E-3. That number jumped to 150 in Autumn 2011. The master's programs have grown from an enrollment of 47 in 2000 to 107 in 2011. Much of this growth is due to the large increase in participation in the distance-learning program, which grew from 11% to 23% of graduate enrollment between 2001 and 2005, and currently comprises 35% of all graduate enrollment in the program. The number of PhD students in the department averaged 35 between 2004 and 2010, but increased to 47 in autumn 2011. Figures E-5 and E-6 provide additional data on graduate admissions and graduations during the 2001-2011 period.

The fraction of underrepresented (URM) minorities in the A&A undergraduate program, shown in Fig. E-4, fluctuated between 3% and 8% between 2002 and 2007, but decreased beginning in 2008, possibly due to the unfavorable state and national economic conditions. Currently, URM enrollment comprises 4% of the undergraduate enrollment. The enrollment of women increased steadily beginning in the 1990s, and grew to represent about 23% of the undergraduate program in 2004 and 2005. However, it has declined during the past six years, and the current level is only 12%, for reasons that are unknown. Underrepresented minorities in the graduate program have increased from 1% in 2001 to 10% in 2011, as can be seen in Fig. E-7. The number of women in the graduate program increased from 13% to 16% over the same period.

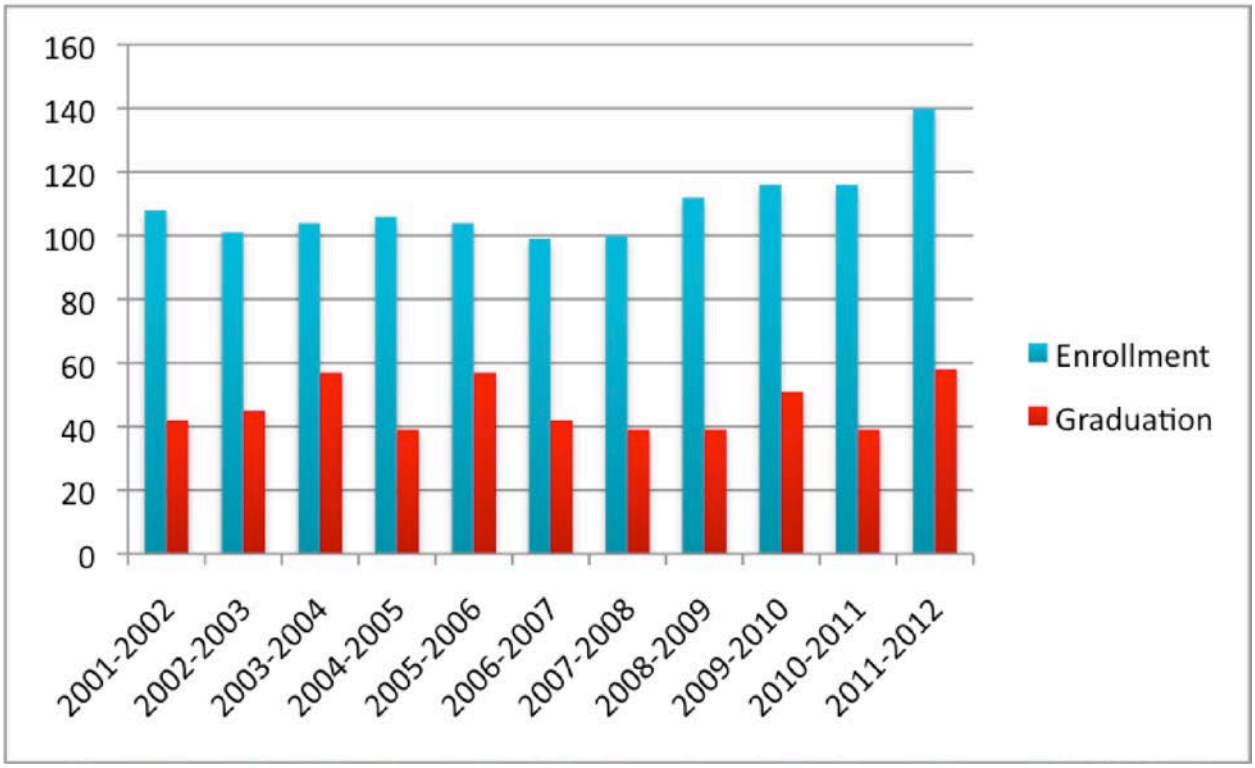

Fig. E-1: Undergraduate enrollment and graduation, 2001-2011

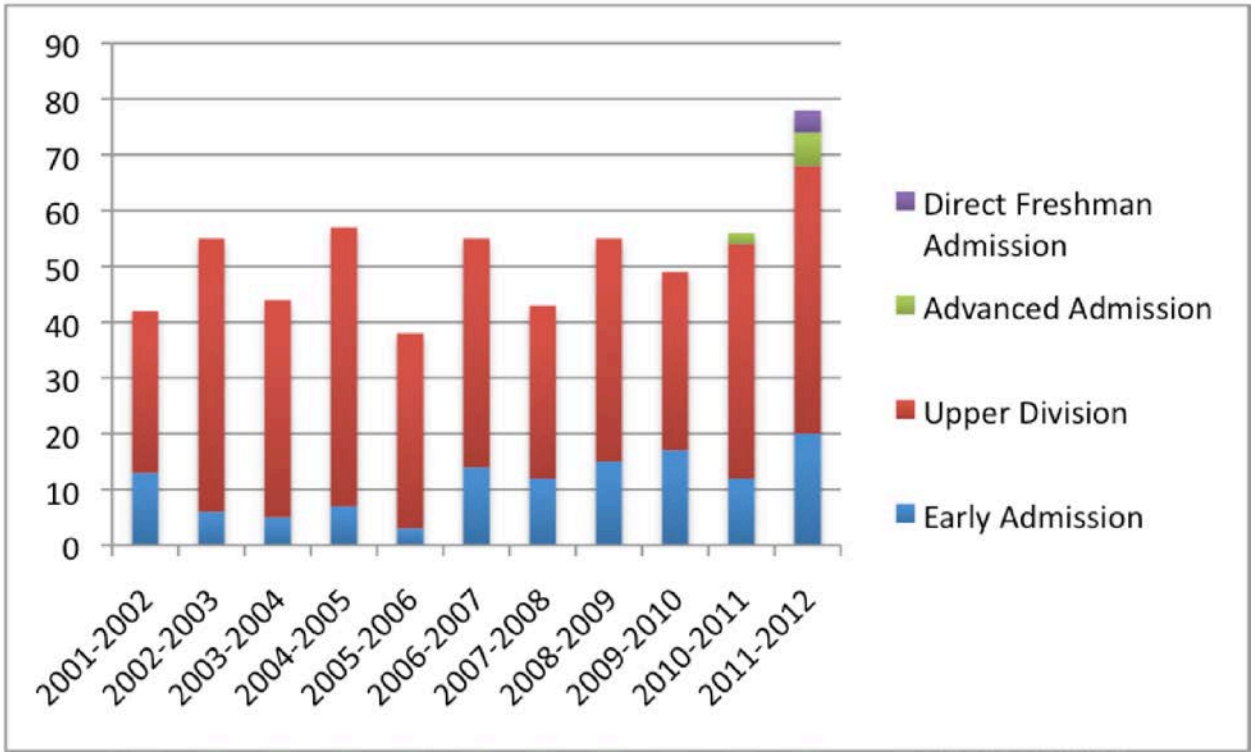

Fig. E-2: Undergraduate admissions, by type, 2001-2011

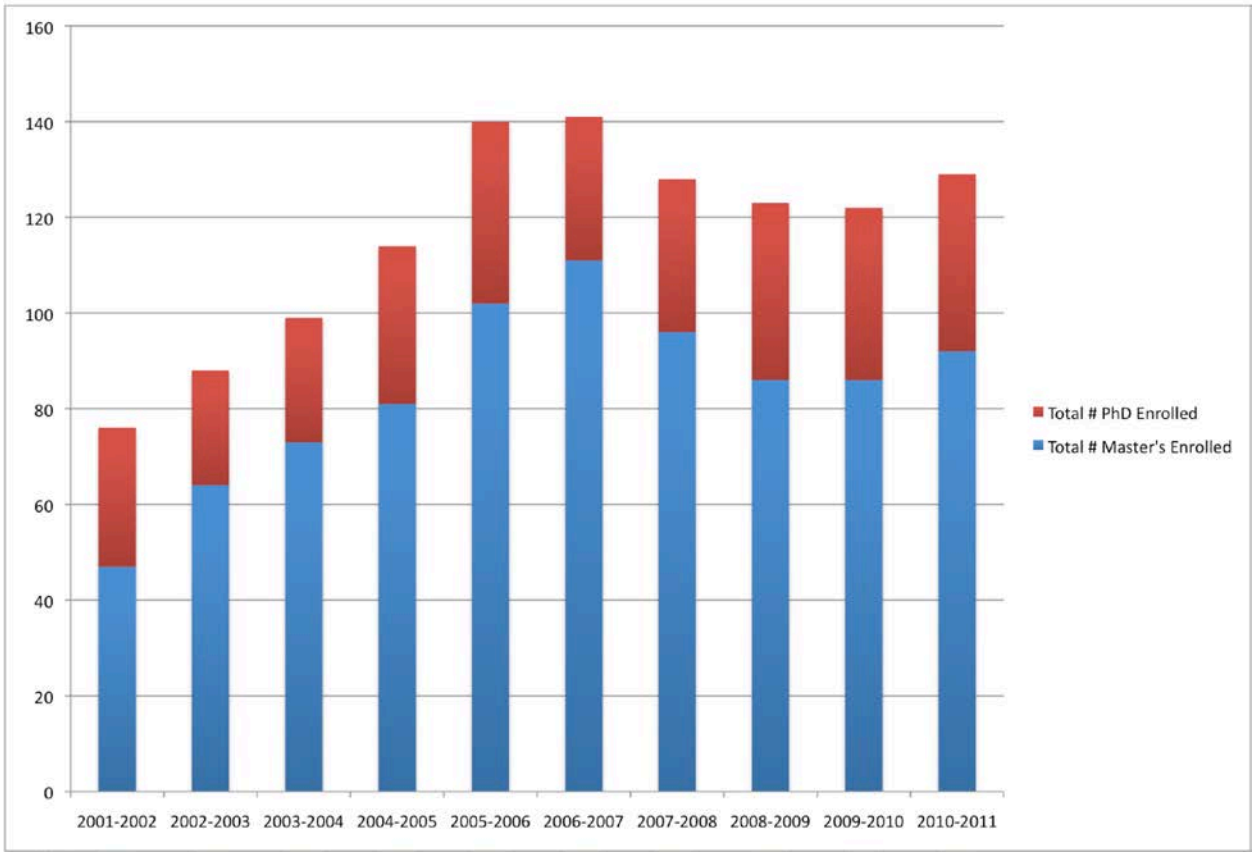

Fig. E-3: Enrollment in the graduate program, 2001-2011

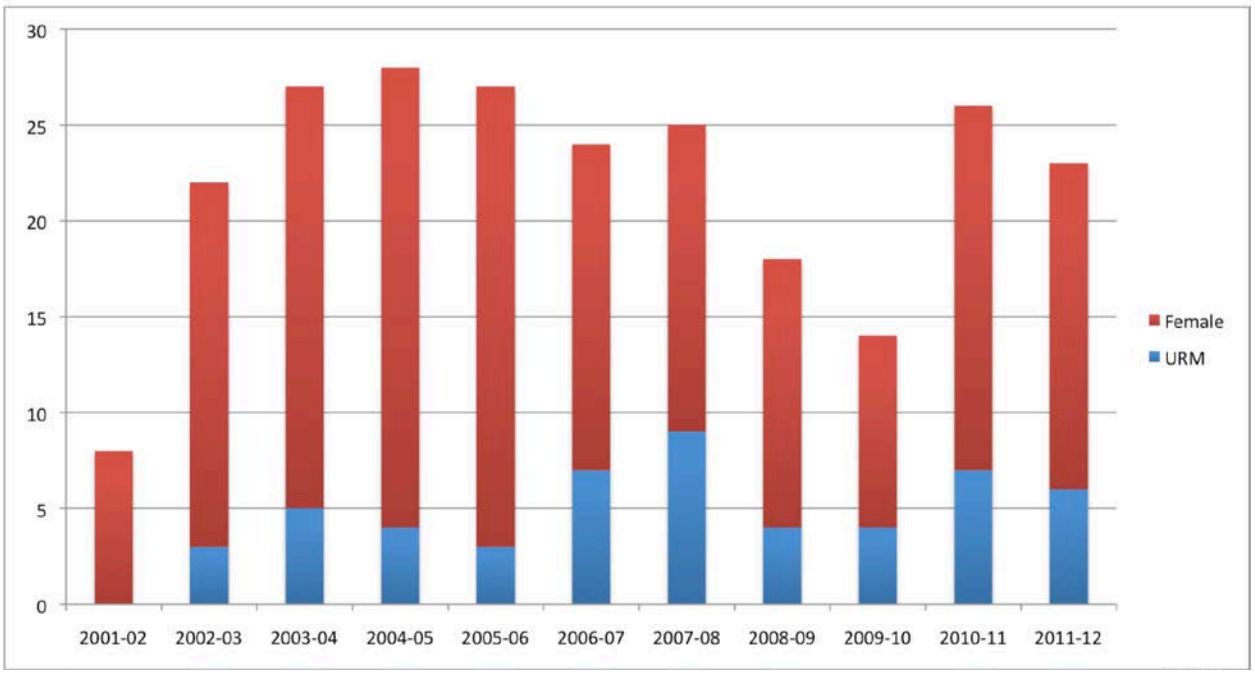

Fig. E-4: Undergraduate underrepresented minority and female enrollment, , 2001-2011

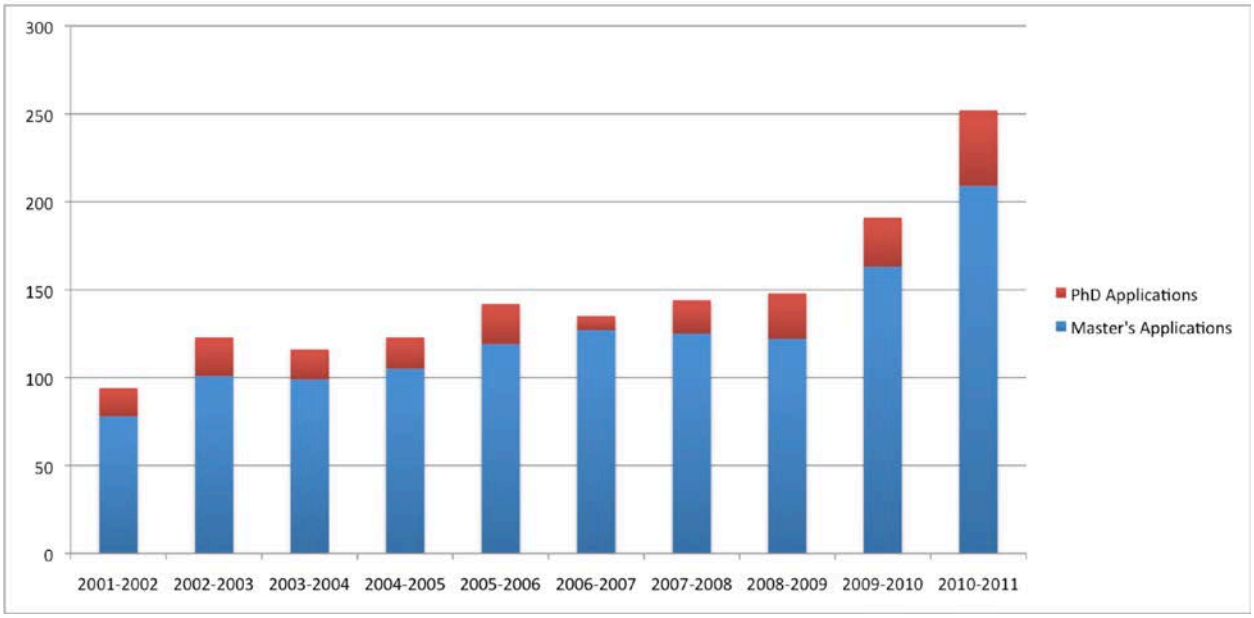

Fig. E-5 Applications to the graduate program, 2001-2011

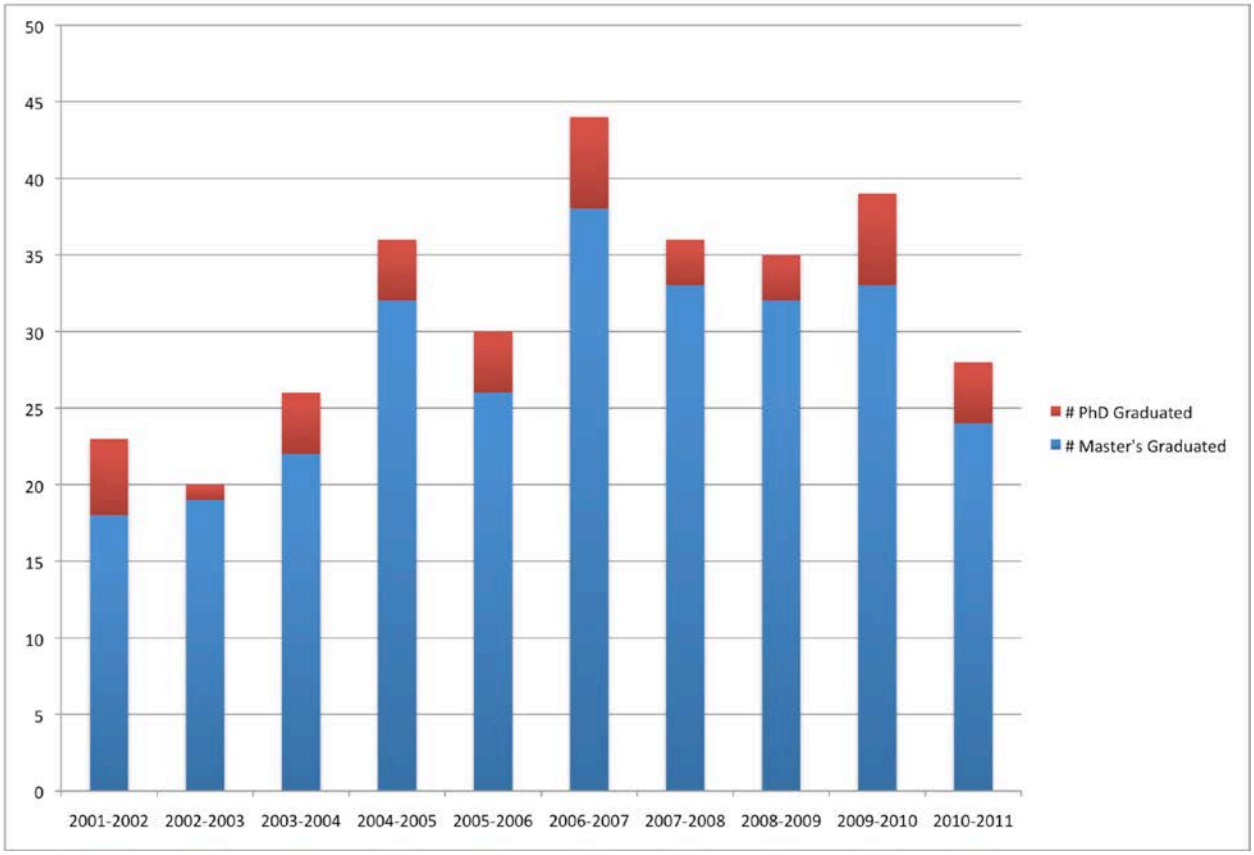

Fig. E-6 Master's and PhD graduates, 2001-2011

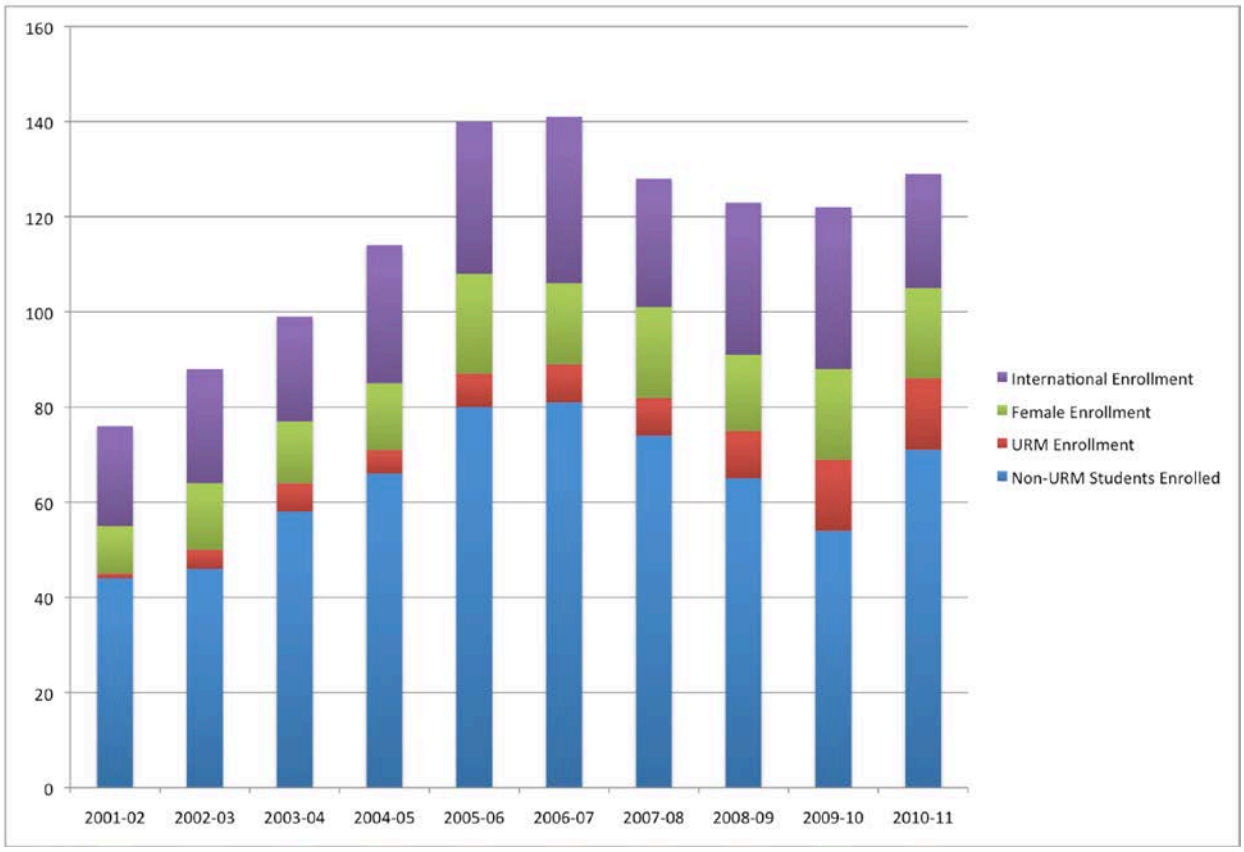

Fig. E-7: Graduate enrollment by type, including URM, female, and International, 2001-2011

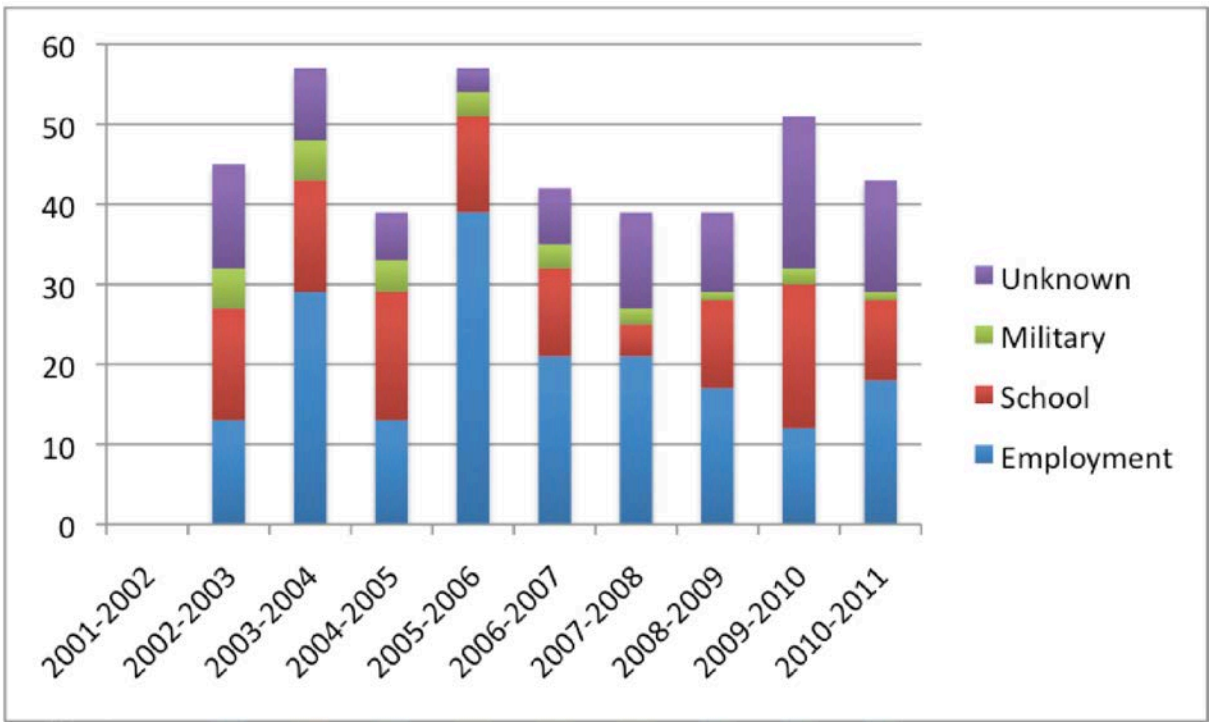

Fig. E-8 Undergraduate employment after graduation, 2001-2011

Table E-1: Master's graduate student exit questionnaire, 2001-2011

Average Ratings (scale of 1 to 5, 5 being highest)	2010-11			2009-10			2008-09			2007-08		
	Unit	COE	UW	Unit	COE	UW	Unit	COE	UW	Unit	COE	UW
Rating of departmental academic standards	4.25	4.24	4.1	4.24	4.13	4.07	3.81	4.12	4.09	4.15	4.26	4.08
Response of recent developments or trends	4.38	4.26	4.27	4.25	4.21	4.26	4	4.22	4.23	4.3	4.29	4.25
Adequacy of research and professional training	3.96	3.98	3.91	3.87	3.93	3.91	3.44	3.97	3.89	3.84	4.09	3.97
Adequacy of space, facilities, and equipment	3.92	3.83	3.9	3.97	3.81	3.78	3.81	3.75	3.72	4.13	3.91	3.76
Satisfaction with supervision and/or guidance	4.17	4.04	3.91	3.94	3.96	3.89	3.5	4.05	3.87	3.85	4	3.89
Confidence in preparation for teaching	3.68	3.6	3.65	3.33	3.57	3.65	2.94	3.44	3.64	3.54	3.59	3.68
Adequacy of teaching preparation for students	3.63	3.73	3.86	3.65	3.68	3.84	3.47	3.63	3.85	3.7	3.75	3.9
Quality of the faculty	4.38	4.37	4.25	4.18	4.25	4.26	4	4.28	4.24	4.18	4.34	4.24
Satisfaction with career mentoring	3.61	3.6	3.53	3.45	3.51	3.55	3	3.6	3.55	3.59	3.65	3.55
Confidence as an independent scholar/researcher in field	4.04	3.89	3.85	3.83	3.86	3.85	3.88	3.86	3.81	3.82	3.85	3.82
Overall quality of the program	4.33	4.18	4.09	4.19	4.09	4.09	3.81	4.11	4.07	4.09	4.18	4.09
Percent who had a paper published in a journal while in the program	8.33%	17.22%	6.42%	5.56%	17.37%	6.03%	3.85%	15.38%	6.46%	12.12%	19.44%	7.96%
Percent who are publishing based on thesis or dissertation	25.00%	27.85%	23.51%	16.67%	28.68%	24.09%	19.23%	31.09%	24.30%	18.18%	32.60%	23.93%
Average Number of Papers Published	1	1.70%	1.70%	1.5	2.1	1.9	3	1.8	1.7	1.8	1.5	1.7
TEACHING EXPERIENCE AT U of W												
Served as grader and/or tutor	25.00%	24.81%	13.55%	27.78%	29.47%	13.68%	42.31%	29.49%	14.63%	39.39%	27.59%	14.42%
Taught laboratory/quiz sections	16.67%	22.03%	12.59%	25.00%	26.58%	13.44%	38.46%	29.17%	14.66%	36.36%	30.41%	14.28%
Taught own class	0.00%	5.06%	6.23%	0.00%	6.32%	7.74%	3.85%	4.81%	9.24%	3.03%	4.70%	7.07%
Other	12.50%	12.41%	16.10%	5.56%	11.84%	16.65%	19.23%	8.97%	16.70%	15.15%	12.85%	17.51%
IMMEDIATE POST-GRADUATION PLANS												
Further graduate study	25.00%	21.99%	11.70%	11.76%	20.77%	13.28%	19.23%		13.16%	18.18%	24.03%	12.90%
Postdoctoral fellowship or research associateship	0.00%	0.26%	0.80%	0.00%	1.09%	0.76%	0.00%		0.63%	0.00%	0.00%	0.93%
Governmental employment	4.17%	4.45%	11.40%	11.76%	6.83%	12.90%	3.85%	20.79%	12.67%	12.12%	5.52%	13.08%
Self-employment	0.00%	1.31%	3.63%	0.00%	0.55%	4.35%	0.00%	0.33%	3.56%	0.00%	0.97%	3.41%
Business/industrial employment	54.17%	63.09%	37.36%	67.65%	59.29%	36.05%	76.92%	8.91%	36.84%	69.70%	60.06%	36.16%
Research University	8.33%	3.40%	3.84%	0.00%	1.91%	3.56%	0.00%	2.31%	3.60%	0.00%	1.95%	3.76%
Comprehensive university or college	0.00%	0.00%	1.45%	0.00%	0.27%	1.40%	0.00%	61.72%	1.43%	0.00%	0.00%	1.72%
Liberal arts college	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.66%	0.00%	0.00%	0.00%	0.00%
Community college	0.00%	0.26%	1.77%	0.00%	0.82%	1.49%	0.00%	0.00%	2.03%	0.00%	0.00%	1.36%
School (K-12)	0.00%	0.00%	11.19%	0.00%	0.00%	9.40%	0.00%	0.00%	9.50%	0.00%	0.00%	9.53%
Not seeking employment or further formal education	0.00%	0.79%	2.07%	0.00%	2.19%	2.32%	0.00%	0.33%	2.13%	0.00%	2.60%	2.01%
Other	8.33%	4.45%	14.80%	8.82%	6.28%	14.49%	0.00%	0.00%	14.46%	0.00%	4.87%	15.13%
								0.66%				
Percentage having secured a position	54.17%	58.73%	48.66%	70.59%	61.81%	49.18%	57.69%	4.29%	50.79%	72.73%	73.03%	53.92%
Secured position preference (first choice)	87.50%	89.80%	82.93%	76.00%	88.14%	83.43%	94.74%		85.62%	96.15%	91.14%	87.81%
Secured position preference (second choice)	12.50%	8.57%	13.48%	20.00%	8.70%	13.28%	5.26%	69.15%	11.72%	3.85%	7.59%	10.17%
Secured position preference (third choice)	0.00%	1.63%	3.59%	4.00%	3.16%	3.29%	0.00%	90.74%	2.66%	0.00%	1.27%	2.02%
Percentage indicating the position is in Washington State	50.00%	79.34%	80.04%	72.00%	81.86%	80.02%	64.71%	7.87%	77.31%	66.67%	76.62%	78.24%
								1.39%				
N=	24	371	3343	31	362	3129	24	84.79%	2857	33	305	2777
								298				

Table E-2: PhD graduate student exit questionnaire, 2001-2011

Average Ratings (scale of 1 to 5, 5 being highest)	2010-11			2009-10			2008-09			2007-08		
	Unit	COE	UW	Unit	COE	UW	Unit	COE	UW	Unit	COE	UW
Rating of departmental academic standards	4.2	4.43	4.37	4.25	4.45	4.36	3.8	4.31	4.27	4	4.3	4.24
Response of recent developments or trends	4	4.48	4.37	4.25	4.56	4.43	4.2	4.37	4.34	3.4	4.32	4.3
Adequacy of research and professional training	4	4.39	4.2	3.5	4.44	4.28	3.8	4.22	4.13	3.4	4.28	4.13
Adequacy of space, facilities, and equipment	4.4	4.13	3.94	3.75	4.17	3.95	3.6	4.08	3.75	2.8	3.94	3.63
Satisfaction with supervision and/or guidance	3.8	4.47	4.23	3.75	4.39	4.26	3	4.17	4.18	3.2	4.17	4.1
Confidence in preparation for teaching	3.2	3.8	3.68	3	3.91	3.8	3.4	3.58	3.65	2.25	3.68	3.6
Adequacy of teaching preparation for students	3.6	4.15	4.14	3.75	4.07	4.19	4	3.95	4.1	2.75	3.87	4.06
Quality of the faculty	4	4.53	4.51	4.75	4.56	4.56	4	4.44	4.48	4	4.41	4.43
Satisfaction with career mentoring	3.2	4.05	3.83	3	3.99	3.95	3	3.75	3.77	2.75	3.81	3.7
Confidence as an independent scholar/researcher in field	4.2	4.35	4.14	4	4.41	4.23	3.8	4.27	4.16	4	4.24	4.1
Overall quality of the program	4.2	4.38	4.29	3.75	4.44	4.35	3.6	4.27	4.26	3.8	4.23	4.15
Percent who had a paper published in a journal while in the program	20.00%	87.37%	72.93%	25.00%	82.02%	67.41%	100.00%	84.09%	70.44%	40.00%	88.37%	68.14%
Percent who are publishing based on thesis or dissertation	100.00%	96.88%	95.14%	100.00%	100.00%	95.04%	100.00%	97.73%	95.76%	100.00%	98.84%	92.25%
Average Number of Papers Published	3	3.9	2.9	2	4.9	3.1	3.8	3.8	3	1	3.2	3.4
TEACHING EXPERIENCE AT U of W												
Served as grader and/or tutor	40.00%	54.08%	44.18%	50.00%	47.78%	45.75%	20.00%	51.69%	41.32%	40.00%	54.02%	45.95%
Taught laboratory/quiz sections	20.00%	58.16%	61.19%	50.00%	66.67%	61.95%	20.00%	59.55%	58.68%	40.00%	56.32%	60.08%
Taught own class	0.00%	21.43%	32.99%	0.00%	17.78%	35.22%	60.00%	28.09%	36.53%	20.00%	22.99%	35.97%
Other	20.00%	15.31%	15.07%	50.00%	17.78%	16.51%	40.00%	17.98%	16.53%	40.00%	13.79%	12.81%
IMMEDIATE POST-GRADUATION PLANS												
Further graduate study	0.00%	0.00%	1.67%	0.00%	0.00%	2.88%	0.00%	1.11%	1.36%	0.00%	0.00%	0.98%
Postdoctoral fellowship or research associateship	60.00%	29.47%	45.15%	25.00%	27.59%	40.27%	60.00%	22.22%	35.59%	0.00%	21.52%	35.49%
Governmental employment	0.00%	4.21%	4.35%	0.00%	5.75%	5.25%	0.00%	2.22%	4.58%	0.00%	2.53%	3.73%
Self-employment	0.00%	0.00%	2.17%	0.00%	1.15%	2.54%	20.00%	2.22%	2.54%	0.00%	0.00%	1.57%
Business/industrial employment	40.00%	50.53%	17.39%	50.00%	43.68%	16.41%	20.00%	42.22%	14.92%	60.00%	58.23%	20.59%
Research University	0.00%	9.47%	16.22%	0.00%	14.94%	17.60%	0.00%	20.00%	17.29%	20.00%	13.92%	13.73%
Comprehensive university or college	0.00%	3.16%	5.69%	0.00%	3.45%	6.09%	0.00%	7.78%	8.14%	0.00%	1.27%	7.65%
Liberal arts college	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%	0.00%	0.00%	4.07%	0.00%	0.00%	4.71%
Community college	0.00%	0.00%	1.17%	0.00%	0.00%	0.85%	0.00%	1.11%	1.36%	0.00%	0.00%	1.76%
School (K-12)	0.00%	0.00%	0.17%	0.00%	0.00%	1.69%	0.00%	0.00%	3.56%	0.00%	0.00%	2.35%
Not seeking employment or further formal education	0.00%	2.11%	1.34%	0.00%	0.00%	0.85%	0.00%	0.00%	2.03%	20.00%	1.27%	0.98%
Other	0.00%	1.05%	4.68%	25.00%	3.45%	5.25%	0.00%	1.11%	4.58%	0.00%	1.27%	6.47%
Percentage having secured a position	100.00%	61.05%	57.12%	25.00%	70.45%	63.96%	80.00%	74.12%	69.95%	60.00%	76.74%	72.50%
Secured position preference (first choice)	60.00%	78.79%	82.44%	100.00%	82.81%	85.02%	100.00%	86.76%	85.00%	66.67%	85.07%	83.55%
Secured position preference (second choice)	40.00%	21.21%	15.12%	0.00%	14.06%	12.08%	0.00%	10.29%	13.33%	33.33%	13.43%	14.10%
Secured position preference (third choice)	0.00%	0.00%	2.44%	0.00%	3.13%	2.90%	0.00%	2.94%	1.67%	0.00%	1.49%	2.35%
Percentage indicating the position is in Washington State	20.00%	26.98%	38.35%	100.00%	38.46%	42.62%	50.00%	39.13%	40.33%	66.67%	50.00%	40.31%
N=	5	94	632	4	88	608	5	88	4	5	86	517

APPENDIX F
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APPENDIX G
A&A DEPARTMENT PEER-EVALUATION PROCESS

Policy and Procedures for Peer Evaluation of Teaching Effectiveness and Student Learning
First Adopted 2/8/91
Amended 3/1/00

Introduction

The department of Aeronautics and Astronautics affirms that the continuous evaluation of the efforts and outcomes of its individual faculty in teaching is an essential part of the measure of a faculty member and his/her contributions to the University for promotion, tenure and merit purposes. The College of Engineering *"Teaching and Service Standards, Measures and Procedures"* document, adopted in June, 1994, outlines the teaching standards and measures to be applied to all Engineering faculty. This department policy outlines the specific department procedures to monitor and evaluate those standards and measures. The goal is to assist our faculty members to improve their effectiveness both in the classroom and in the direction of individual student projects.

Review Committee

The review committee will consist of three to four faculty members appointed by the Department Chair. These will be Professors or Associate Professors and will be chosen, to the extent possible, to represent different technical disciplines. Appointments will be for a period of three years, with the initial terms being staggered to provide continuity in the committee. The committee is responsible for carrying out the procedures outlined here, and maintaining records of all actions.

Evaluation Frequency

All faculty members including the Department Chair will be evaluated. Assistant Professors will have a mini- review conducted by at least one member of the review committee each quarter, and will have at least one full committee review each year. Associate Professors will have a full committee review each year. Full Professors will have a full committee review at least once every three years. The committee may decide to hold reviews on a more frequent schedule if special circumstances warrant it.

A faculty member holding a joint appointment may choose to be evaluated in only one of his/her departments, with the understanding that the results of the evaluation will be made available to the joint departments. The reviews will focus on information since the last review.

FACULTY RECORDS

Each faculty member should maintain records of all courses taught, identifying the number of students. For each course taught the faculty member should maintain an outline of the actual content, a set of all course notes, and sample exams and homework for the most recent three years.

In addition, each faculty member should maintain as a part of his/her records a portfolio of the evaluation of his/her teaching efforts, results and effectiveness. This portfolio should as a minimum include the following:

a) Copies of the University student course evaluation for each course the faculty member teaches, including the overall ratings and the individual student comment sheets.

b) For each course, after the close of the quarter the faculty member should prepare a short statement of his/her evaluation of teaching effectiveness, student learning and an interpretation of the student evaluations and comments. That statement should include an evaluation of what went well, and what aspects should be changed in the future.

c) Records and results from any other course evaluations obtained, such as reviews by CIDR office.

d) Listing of workshops and seminars attended that relate to teaching techniques and evaluation techniques.

Procedure

The evaluation will begin with an interview of the reviewee by the Review Committee. In this interview the reviewee will have the opportunity to describe any of his/her professional activities which he/she deems to be of importance to his/her teaching effectiveness. This exposition to the committee may include the following:

1) Presentation of his/her records on teaching described above

2) Presentation of his/her portfolio on teaching effectiveness.

3) Any of new course material, showing how and why it came about, how it fits into the overall departmental and/or college programs, and what is planned for the future.

4) Scholarly works such as textbooks, course notes, problem sets, study manuals, special software, video-tapes, or other materials which have already been used.

5) Specific instances where the faculty member's research, professional practice, or other scholarly pursuit has contributed directly to the material taught in his/her courses or to the direction of graduate student theses and dissertation work.

6) Modifications made to existing courses to meet needed improvements in the courses.

7) Development of laboratories used for instruction in credit bearing courses.

8) Direction of individual student projects and graduate student research.

9) Participation in special tutoring programs or in student advising on technical or professional matters.

10) Any special recognition or awards received for teaching.

11) The grading policy or practices used in undergraduate and graduate courses.

12) Other activities not specifically mentioned here.

In addition to the interview, the reviewee may wish to invite a member of the Review Committee to attend a regular class session as an observer, or to view a video-tape of a regular class session. A visit to a laboratory or to a field site is also an option available to the reviewee.

Report

The Review Committee will prepare a one page report to the Department Chair outlining what it did and giving its evaluation of the faculty member's teaching effectiveness. Elements of strength in the faculty member's approach and style, as well as points where improvements could (or should) be made are to be reported. This report will be a peer judgement based primarily on the twelve items outlined above.

The Department Chair will subsequently transmit the report to the faculty member. The Chair may also at his/her discretion transmit results of these reports to the Promotion and Tenure Committee.

Appendix H

Alumni Achievements and Awards

Describe how program graduates have had an impact on the field either academically or professionally:

Distinguished Alumni:

- Dennis Muilenburg (MS 90) president and CEO of Boeing Defense, Space & Security
- Suzanna Darcy-Hennemann (BS 81) production test pilot and captain of the 747p400 and 777. Set the nonstop distance record for a commercial jet.
- Lars Anderson (BS 68) retired from a distinguished career at Boeing in 2007; however, three years later the company called him back to serve as Vice President of 777 Product Development for Boeing Commercial Airplanes, responsible for planning the future of Boeing's twin-aisle airplane. He reports to Commercial Airplanes President and Chief Executive Officer Jim Albaugh and also serves on his Senior Advisory Group.
- Scott Crossfield (BS 49, MS 50) first to fly twice the speed of sound; inducted into the National Aviation Hall of Fame
- George Jeffs (BS 45, MS 48) VP of Rockwell. Directed the Apollo program; responsible for the design, engineering, and construction of the Space Shuttle; received the Presidential Medal of Freedom, two NASA Distinguished Public Service Medals, and election to the National Academy of Engineering. UW Alumnus Summa Laude Dignatus.
- Louis B. Gratzer (BS 44, MS 51, PhD 68) Senior Vice President of Aviation Partners, Inc. (API), and is responsible for the product development of aircraft performance enhancement systems.
- Joe Sutter (BS 43**)** was a key figure in the development of Boeing's 747 aircraft. He headed the 747 division, and later served as Vice President of Boeing Commercial Airplane Company. He was elected to the National Academy of Engineering, is a fellow of the Royal Aeronautical Society, and was presented the Medal of Technology by President Reagan. UW Alumnus Summa Laude Dignatus.
- Four US Astronauts have graduated from our program: Greg C. Johnson (BS 77), John Fabian (PhD 84), Jim Dutton (MS 94), Dominic Antonelli (MS 02).

For a complete listing of our distinguished alumni, see our web page:
http://www.aa.washington.edu/alumni/previousAwards.html

Alumni Achievements:

Dr. Manav Bhatia, (PhD 07), a postdoctoral fellow at Virginia Tech, is well known for his leadership role in the area of design optimization of truss braced wing configurations.

Daniel Klein (MS 05, PhD 08) after completing a postdoctoral fellowship at UC Santa Barbara, he accepted a position at Intellectual Ventures, outside the realm of aeronautical engineering, working on HIV modeling toward eradication of this disease.

Peter Norgaard (BS 04) is finishing his PhD at Princeton this Autumn, and will begin a one-year American Institute for Physics Congressional Fellowship working for the US Congress in Washington, D.C.

Kakani Young (BS 04) is a postdoctoral scholar at Woods Hole Oceanographic Institution and a recipient of the 2011 National Geographic Emerging Explorer Award, the 2010 Devonshire Foundation Postdoctoral Scholar Award, and the National Defense Science and Engineering Graduate Fellowship at Caltech.

Both Major C. B. Cain (MS 01) and Major Jeremy Wimer (MS 03) were selected as elite test pilots and are serving at Edwards Air Force Base.

Valerie Izzo (MS 01, PhD 04) was awarded a DOE Fusion Postdoctoral Fellowship at MIT.

Ben Davenport (BS 99) is a major in the US Marine Corps and served several tours of duty in Iraq. Ben was captain of the "Purple Foxes" a Marine Helicoptor Squadron stationed in Iraq, which performed casualty evacuation missions. He received a 2010 Chinese Olmsted Scholarship to study Chinese diplomacy and international relations. The scholarship is designed to equip outstanding young military leaders to serve in positions of great responsibility in the US Armed Forces.

Laila Elias (BS 98), Rob Grover (MS 98), Derek Inaba (BS 02), Marleen Martinez (BS 06), Ed Odell (BS 96), and Richard Warwick (BS 94, MS 96) worked on recent space programs, at NASA/JPL and Lockheed Martin, such as the Phoenix Mars Lander mission, Spirit and Opportunity Mars Exploration Rover missions, and Mars Reconnaissance Orbiters. Ed O'Dell (BS 96), who passed away earlier this year, received a public service medal for his work on the Mars Exploration Rover.

Ki-Seuk Lee (BS 96, MS 98, MEngr 00) is the coordinator for international affairs and foreign certifications for the Korea Testing Laboratory (KTL). He travels globally representing the Korean government.

David Aronstein (PhD 94) is a Senior Technical Fellow at Cessna Aircraft.

Alumni Entrepreneurs:

Benjamin Triplett (PhD 08) is co-founder of Sector 7G Systems, which develops nonlinear parameter estimators using unscented Kalman filter algorithms for modeling of the dynamics of large supply vessels and smaller pleasure craft.

Bill Vaglienti (BS 96) is co-founder of Cloud Cap Technology, a leading Unmanned Systems sensor development company (currently a wholly-owned subsidiary of B.F. Goodrich Aerospace).

Jason Andrews (BS 94) is founder and President and CEO of Andrews Space, Inc.

Significant awards, noteworthy presentations, and activities by graduates and undergraduates that have had an impact on the field while in the program:

Student Awards:

- Doctoral students Brian Hinson, Keon Vereen and Kristina Wang are 2011 National Science Foundation Fellows.
- Doctoral student Keon Vereen is a 2011 Ronald E. McNair Scholar.
- Doctoral student Noah Reddell is a 2011 Department of Energy Computational Science Graduate Fellow, and Gordon C. Oates Memorial Endowed Fellowship recipient.
- A manuscript submitted by doctoral student Francesco Deleo was selected as Best Paper at the 2011 Society of Plastic Engineers Automotive Composites Conference & Exhibition.
- MSAA student Philip Gray was the first recipient in 2011 of the new William E. Boeing Fellowship in Aeronautics & Astronautics, honoring its founder's vision of close academic and industrial collaboration and continuing his legacy of excellence and diversity of thought.
- Doctoral student Gregory Rixon is a 2011 recipient of a Washington NASA Space Grant Fellowship.
- Doctoral student Jens von der Linden received an Honorable Mention from the prestigious NSF Graduate Research Fellowship Program in 2010. Also, in October 2009 he and his team won first prize in the business plan competition of the Technopreneurship & Innovation Program (TIP) organized by the UW Electrical Engineering department. His team worked on a project for an ultrasound cancer treatment diagnostic.
- PhD Candidate Jonathan Wrobel was the recipient of the prestigious MIT Lincoln Laboratory Fellowship in 2010-11.

- Chris Lum, PhD Student, received the best student paper award at the AIAA Infotech@Aerospace conference in April, 2009.
- Genia Vogman was among the first group of recipients of a NASA Aeronautics Scholarship as a junior in 2008. The award is designed to encourage and foster highly motivated students to pursue and excel in disciplines of aeronautics so that they can work toward solving key challenges facing aviation in the 21st century.
- Doctoral student Chris Lum, received a Washington NASA Space Grant Fellowship in 2007 and an Osberg Family Trust Fellowship in 2005. Also, in 2008, he and master's student Matthew Rowland and Professor Rolf Rysdyk received the outstanding paper award at the 26th AIAA Aerodynamic Measurement Technology and Ground Testing Conference.
- Youngjun Kim, PhD student, was a finalist in 2006 to become the first Korean Astronaut. The initial group of applicants was 1,200. He was flown to Korea for physical and mental tests; the group was culled to 500, then 245, then 30. Youngjun was among this select final group.
- Seniors Nathan Hicks, Natalia MacDonald, and Mary Williams were selected to receive National Science Foundation/Computer Science, Engineering and Mathematics Fellowships for 2005 – 2006.
- Several of Professor Dana Dabiri's students received 2005 Mary Gates Scholarships for their research with him: Colin Adams for "Preliminary Research on the Ionic Wind Effect," Noel Pelland for "Large-Scale Three-Dimensional Digital Particle Image Thermometry and Velocimetry Camera Design," Toru Yamasaki for "3D Digital Flow Visualization of Convection Cells," and senior Amanda Horike for "Ionic Wind Lifter."
- Awarded at the 2004 and 2005 Region VI AIAA Student Conferences: Peter Norgaard received first place in the undergraduate category 2004. Stuart Jackson received a special award for best presentation 2004. In 2005 Sanjoy Som received first place in the graduate competition.
- Grad student Adi Salehuddin received the 2004 Elizabeth Gould Award for International Understanding and the National Bureau of Asian Research Jane T. Russell Award for Leadership and Service.
- Master's student Sebastian Stolle received the best student paper award at the AIAA Digital Avionics Systems Conference in October 2003.
- Doctoral students David Rathbun and Brian Capozzi, master's student Sean Kragelund and post-doc Anawat Pongpunwattana received the best paper in conference award at the AIAA Digital Avionics Systems Conference in October, 2002.

APPENDIX I
Course Changes 2001-2011

Change Date	Course # (Old)	Course # (New)	Course Title (Old)	Course Title (New)	Reason
9/25/00		AA 320		Aerospace Instrumentation	Students were dissatisfied with EE 215 and EE306 electrical engineering courses offered in EE department. AA 320 is a lab-based, hands-on, 3-credit course that introduces A&A students to basic electronics and instrumentation used in aerospace systems. A fully-equipped 8-bench lab was set up for the course. *NOTE: This course was introduced just after previous 10-Year Report was submitted*
2/21/01	AA 321. 322	Same	Aerospace Laboratory I, II	Same	These undergraduate lab courses were upgraded to include a more in-depth writing component than ever before, in response to consistent alumni feedback about how important report writing experiences had been to their careers. (Now that the College's writing requirement appears slated for elimination we are adjusting courses to ensure that the University writing requirement is being met without increasing time to degree.)
3/29/05		AA/EE/ME 549	Estimation and System Identification	State Estimation and Kalman Filtering	The old course was split into two different courses. This one kept its current number.
3/29/05	AA599	AA/EE/ME 578	Special Projects	Optimization in System Sciences	Course was previously taught as "Special Topics." Students are better served if a properly named course appears on their transcripts.
3/29/05	AA/EE/ME 582	AA/EE/ME 582	Digital Control II	Introduction to Discrete Event Systems	Updated in response to increasing demand for computer modeling and controller design techniques applicable to discrete event systems. Offered in collaboration with electrical and mechanical engineering departments.
3/29/05	AA 599	AA/EE/ME 594	Special Topics	Robust Control	As one of the foundations of modern control theory, robust control is of great importance to the controls curriculum. This new course remedies the absence of this conent and enhances graduate student knowledge.
3/29/05		AA/EE/ME 585		System Identification and Adaptive Control	This course was developed when the state estimation and kalman filtering course was split into two courses. The content in this course was further developed to provide students with advanced experience in system identification and adaptive control.
4/25/05	EE/ME 583	AA/EE/ME 583	Special Topics in Solid Mechanics	Nonlinear Control Systems	As part of the robotics, controls, and mechatronics restructuring across departments, this course was updated to include AA content and AA faculty instruction.
4/25/05	ME 599	AA/EE/ME 593	Special Topics	Feedforward Control	This is the only couse that emphasizes feedforward control in any of the AA/EE/ME departments, and therefore enhances the graduate controls curriculum.
6/6/05		AA 560		Plasma Diagnostics	Knowledge in this class helps experimentalists make measurements, and assists in understanding and assessing plasma physics literature. Course was previously taught as "Special Topics." Students are better served if a properly named course appears on their transcripts.
3/29/05		AA/EE/ME 581	Digital Control I	Digital Control	The material in this course was changed to reflect the merger of Digital Control I & II

3/29/06		AA 499	Special Projects	Undergraduate Research	To satisfy industry recruiters' strong interest in students having undergraduate research experience, and to encourage students to consider graduate school.
11/14/06		AA 299		Undergraduate Research	Created for freshmen and sophomores to encourage them to participate in research sooner (recruitment)
11/14/06		AA 498		Special Topics	For experimental courses or one-time Special Topics, and allow for a broader range of topics.
12/13/06		AA 545		Computational Methods for Plasmas	Covers material needed for students to use & write computer tools to study plasmas. Provides info required to understand computational methods. Course was previously taught as "Special Topics." Students are better served if a properly named course appears on their transcripts.
3/5/07		AA/EE/ME 597		Networked Dynamic Systems	Proposed as an integral part of an NSF proposal. Focus pertains to one of the most active areas of research in systems and control theory
3/21/07		AA/EE 570		Manifolds & Geometry for Systems & Control	Provides material not previously offered to students in Engineering. Material is necessary for state-of-the-art research in non-linear control systems.
3/21/07		AA 580		Geometric Methods for Non-Linear Control Systems	Provides material not previously offered to students in Engineering. Material is necessary for state-of-the-art research in non-linear control theory
5/23/07	AA 101		Introduction to Air and Space Vehicles Space Vehicles		Course was removed from curriculum because it suffered a precipitous drop in enrollment following a very successful run of nearly 10 years. What caused the drop is unclear but the huge initial success of the course motivated other Engineering departments to design similar introductory courses in their fields, which could be taken as Natural World credits by non-engineering students. We think the proliferation of such courses led to a dilution of enrollment in ours.
5/23/07	AA 308, AA 309		Computer Tools I & II		Courses removed from curriculum because students and faculty did not feel these 1-credit courses were providing what was needed. This course sequence was replaced by a single 3-credit course in the Applied Math department (AMATH 301, Beginning Scientific Computing).
5/23/07	AA 497/597		Aerospace Industry Tours		Course removed from curriculum: After just a few years, students began to lose interest, and this offering was also too costly and time-consuming.
6/20/07		AA/INDE 470		Systems Engineering	In response to alumni suggestions to provide students with more exposure to systems thinking and engineering management. This course is joint-listed with the Industrial & Systems Engineering department, and has been taught by instructors from local industry (Aerojet, Boeing.). It is an upgrade of the former, dormant IND E 280 systems course.
5/20/08		AA 538		Introduction to Structural Optimization	Introduces design-oriented analysis; surveys state-of-the art in commercial codes and industry applications.
3/17/09		AA 496		Undergraduate Seminar	An existing Undergraduate seminar for A&A juniors was expanded to include freshmen and sophomores, a course website was initiated, and an end-of-quarter quiz administered. The inclusion of lower division students better engaged them before their junior year, and gave the department a new recruiting tool.
4/21/09		AA 198		Special Topics in Aeronautics & Astronautics	For the department's participation in the UW's Early Fall Start Program (recruitment)
4/21/09	AA 506	AA 506	Vortex Dominated Flows		Added AA 503 (to be foundational fluids course) as a prerequisite.
4/22/09	AA 575/CEE 508	AA/ME 503	Continuum Mechanics	Continuum Mechanics	The fluids curriculum did not adequately emphasize the foundations of fluid mechanics. This now becomes the first fluids course for fluids grad students.

5/21/09		AA 598		Special Topics in A&A	Offers newly developed courses to graduate students under a more appropriate title (previously offered as 599--independent study).
6/16/09		AA 260		Thermodynamics	Chemical Engineering dropped its Chem E 260 course in favor of a new thermodynamics course more suitable to Chem E, Bioengineering, and Biology students. This new Chem E course did not meet our requirements, thus leading us to continue to offer the former thermodynamics course.
9/19/09		AA 534		Integrity of Composite Aircraft Structures	Unique new course, applied in nature, focusing on transport aircraft structures.
12/27/09		AA 545		Computational Methods for Plasmas	Covers material needed for students to use and write computer tools to study plasmas. Provides info required to understand computational methods. Course was previously taught as "Special Topics." Students are better served if a properly named course appears on their transcripts.
5/18/10	AA 543	AA 543	CFD I	Computational Fluid Dynamics (CFD)	Changed name from CFD I to CFD, since CFD II was changed to Turbulence Modeling
5/18/10	AA 544	AA 544	CFD II	Turbulence Modeling & Simulation	Teaches students to develop computer codes for turbulent flows, and gives them a more complete CFD curriculum in conjunction with AA 543..
6/15/10	AA/INDE 595	AA/INDE 595		Global Integrated Systems Engineering (GISE)	Changed from 3-qtr course to 2 linked qtrs, moved seminars to autumn quarter only
8/24/10	AA 507	AA/ME 507	Aerodynamics of Viscous Fluids I	Fluid Mechanics	Restructured as a first year graduate fluids course to follow continuum mechanics. Joint with ME 507.
8/24/10	AA 508	AA 508	Aerodynamics of Viscous Fluids II	Turbulence	Former course title did not reflect content of what was taught (turbulence).
1/18/11		AA 533		Materials and Processing Technology of Aero Composites	Focus on FAA regulations and industry analysis approaches. Proximity to Boeing and FAA Certification Office makes this applied course with a focus on transport aircraft structures unique in the nation.

COURSE CHANGES 2001-2011
BY DISCIPLINE

CONTROLS

AA 528	Spacecraft Dynamics and Control
AA 549	State Estimation and Kalman Filtering
AA 570	Manifolds and Geometry for Systems and Control
AA 578	Optimization in Systems Sciences
AA 580	Geometric Methods for Non-linear Control Systems
AA 581	Digital Control
AA 582	Intro to Discrete Event Systems
AA 583	Nonlinear Control Systems
AA 585	System Identification and Adaptive Control
AA 593	Feedforward Control
AA 594	Robust Control
AA 597	Networked Dynamics Systems

FLUIDS

AA/ME 503	Continuum Mechanics
AA 504	Compressible Fluid Mechanics
AA 506	Vortex Dominated Flows
AA 507	Fluid Mechanics
AA 508	Turbulence
AA 524	Aeroacoustics
AA 525	Special Topics in Advanced Airbreathing Engines
AA 543	Computational Fluid Dynamics
AA 544	Turbulence Modeling and Simulation

PLASMA

AA 545	Computational Methods for Plasma
AA 538	Introduction to Structural Optimization
AA 560	Plasma Diagnostics
AA 564	Kinetic Theory/Radiative Transfer

STRUCTURES

AA 531	Integrity of Metallic Aircraft Structures
AA 533	Materials and Processing Technology ofAerospace Composites
AA 534	Integrity of Composite

CROSS-DISCIPLINARY

AA 101	Introduction to Air and Space Vehicles
AA 198	Special Topics in Aeronautics and Astronautics
AA 260	Thermodynamics
AA 299	Undergraduate Research
AA 308, 309	Computer Tools I, II
AA 320	Aerospace Instrumentation

AA 321, 322	Aerospace Laboratory I, II
AA/IND E 470	Systems Engineering
AA 496	Undergraduate Seminar
AA 497/597	Aerospace Industry Tools
AA 498	Special Topics
AA 499	Undergraduate Research
AA 527	Space Power Systems
AA 595	Global Integrated Systems Engineering
AA 598	Special Topics in Aeronautics & Astronautics

Appendix J

Washington State Department of Commerce

Washington Council of Aerospace

Report to the Governor and Legislature

February 7, 2011


Department of Commerce
Innovation is in our nature.
WASHINGTON COUNCIL ON AEROSPACE
REPORT TO THE GOVERNOR AND LEGISLATURE
February 7, 2011

Table of Contents

This report was prepared in response to **Executive Order 09-04**, establishing the Washington Council on Aerospace. The council was tasked with finding ways to:

- Improve coordination, responsiveness, and integration of the state's aerospace training, education, research, and development programs to meet industry needs;
- Enhance the state's economic climate for the industry;
- Provide a forum for industry, labor and government to collaborate to ensure the needs of this vital industry are met in a timely and effective manner; and
- Ensure that Washington remains the best place in the world to design and manufacture aircraft and grow jobs in the aerospace industry.

The Washington Council on Aerospace is an ongoing effort for private and public partners to collectively identify and take actions that make Washington state government more responsive to the needs of the aerospace industry in Washington.

COUNCIL MEMBERS

- Rogers Weed, Director, Department of Commerce, Council Chair
- Larry Brown, Legislative and Political Director, IAM #751
- Don Bennett, Executive Director, Higher Education Coordinating Board
- Charlie Earl, Executive Director, Washington State Board for Community and Technical Colleges
- Phyllis Wise, Interim President, University of Washington
- Elson Floyd, President, Washington State University
- Sen. Mike Hewitt, R-Walla Walla
- Sen. Steve Hobbs, D-Lake Stevens
- Randall Julin, General Manager, Absolute Aviation Services
- Rep. Phyllis Kenney, D-Seattle
- Stan Sorscher, Legislative Director, Society of Professional Engineering Employees in Aerospace (SPEEA)
- Rep. Judy Warnick, R-Moses Lake
- Benjamen Hempstead, Mechanical Engineering Lead, Electro Impact
- Laura Peterson, Vice President for NW State & Local Government Operations, The Boeing Company

FORMER MEMBERS

- Michael Zubovic, Vice President, Aviation Technical Services, Inc.
- David Schumacher, Director of Government Affairs, The Boeing Company
- Ann Daley, Executive Director , Higher Education Coordinating Board
- Mark Emmert, President , University of Washington

RECOMMENDATIONS FOR NEW MEMBERSHIP

- Eleni Papadakis, Executive Director, Workforce Training & Education Coordinating Board
- Additional industry representation

EXECUTIVE SUMMARY

2010 was the first full year of operation for the Washington Aerospace Council. Its mission is to ensure the continued health of the state's aerospace industry as measured by industry employment numbers. It is tasked to focus in three initial areas: Economic Development, Workforce Training and Research. This past year, the group shifted from idea generation to work plan implementation, meeting six times over the course of the year to explore and develop the action items identified in its work plan.

In the report that follows you will find an overview of the industry's employment trends over time, both in Washington and in other aerospace states. That is followed by specific policy recommendations that surfaced over the course of the past year. After that, you will find the Council's work plan with a recap of 2010 actions and a view of where the group is headed in 2011 on each item. Finally, there are a series of Appendices that provide more detail on several of the policy proposals that are surfacing through the Council.

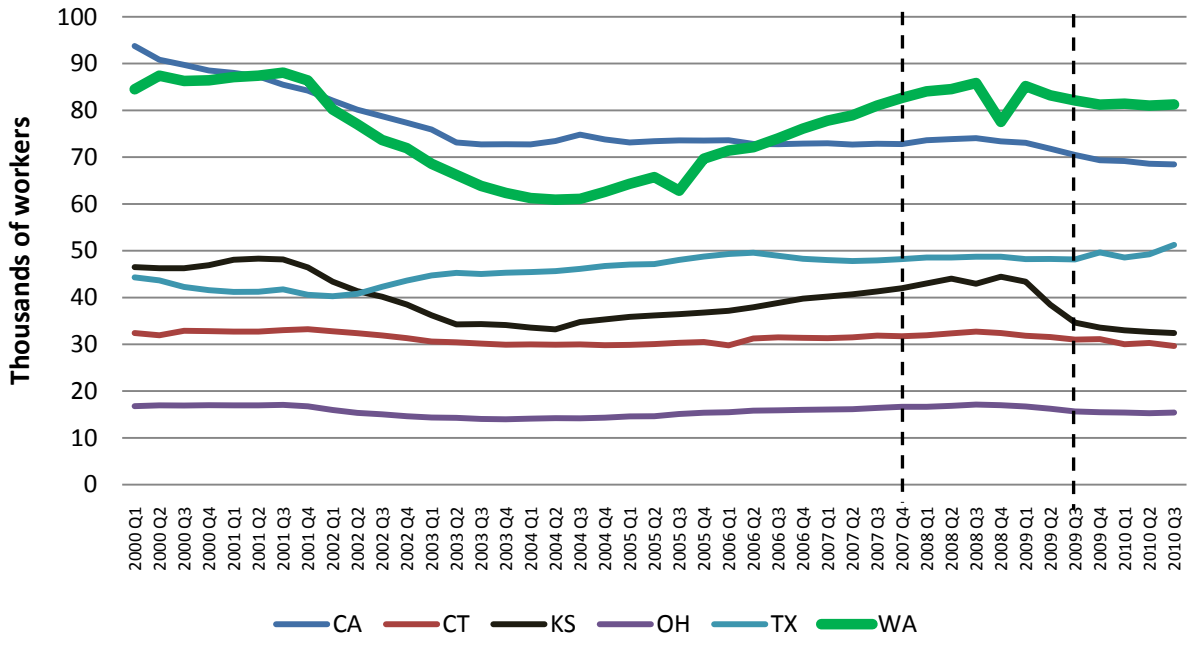
While the Council is very aware of the difficult budget environment that our state's policy makers face, we believe it is our responsibility to ensure that the State Government knows where some of the biggest opportunities lie to improve the health of the industry in the state through policy or budget choices. We look forward to interacting with the Governor and legislators on these ideas and to continuing our work on behalf of one of our state's most important industries.

AEROSPACE INDUSTRY TRENDS

Employment and Jobs

Aerospace jobs continue to show a slight quarterly decline through the first three quarters of 2010. After a 4.8% year-over-year increase in employment in Q4 2009 (artificially buttressed by the effects of the Q4 2008 Boeing machinists strike), year-over-year aerospace employment growth in Washington has been negative for the remaining quarters, with declines of 4.4%, 2.6%, and 1.1%. Of the six states compared below (**Figure 1**), Texas is the only one to have positive year-over-year growth in Q3 2010 (6.5%). In fact, Texas is *the only state* to have exhibited overall positive growth between Q4 2009 and Q3 2010, while Kansas saw a sizable year-over-year decline in its aerospace industry employment over this period, with declines of 24.5%, 24.0%, 15.2%, and 6.5% (Q4 2009 – Q3 2010). While growth seems to have tapered off in Washington, aerospace employment levels remained substantially above levels in 2004. This data also does not capture employment in suppliers not classified by the North American Industry Classification System (NAICS) as "aerospace," such as many tooling, electronics, and composites companies that do significant aerospace-related work.

Figure 1. Aerospace Workforce by State



Source: U.S. Bureau of Labor Statistics, Current Employment Statistics (CES) database, various years

Even though the U.S. Bureau of Labor Statistics does not publish occupation by state and industry, we have identified occupations that are relevant to the aerospace sector. Among these, from 2008 to 2009 (the most recently available data), the largest net declines (in absolute number of jobs) were:

- computer software engineers, applications (1,740 jobs lost);
- shipping, receiving, and traffic clerks (1,040 jobs lost);
- first-line supervisors/managers of production and operating workers (830 jobs lost); and
- aircraft structure, surface, rigging, and systems assemblers (830 jobs lost).

(**Table 1**).

It is important to note that a large segment of Washington's aerospace employment base includes a higher percentage of non-shop floor occupations. In 2009, for instance, there were more than 19,000 engineers employed in the aerospace sector (NAICS 3364), equal to roughly 23% of total aerospace employment.[1]

Washington remains the state with the largest aerospace workforce. In aerospace engineering, the state ranks third behind California and Texas, though our concentration (as measured by the labor location quotient) is now second behind Kansas (**Figure 2**). It is difficult to identify the exact reasons for these changes in employment. The impact of the global recession may have been partially mitigated by the aerospace business cycle, which responds to long-term production and delivery schedules.

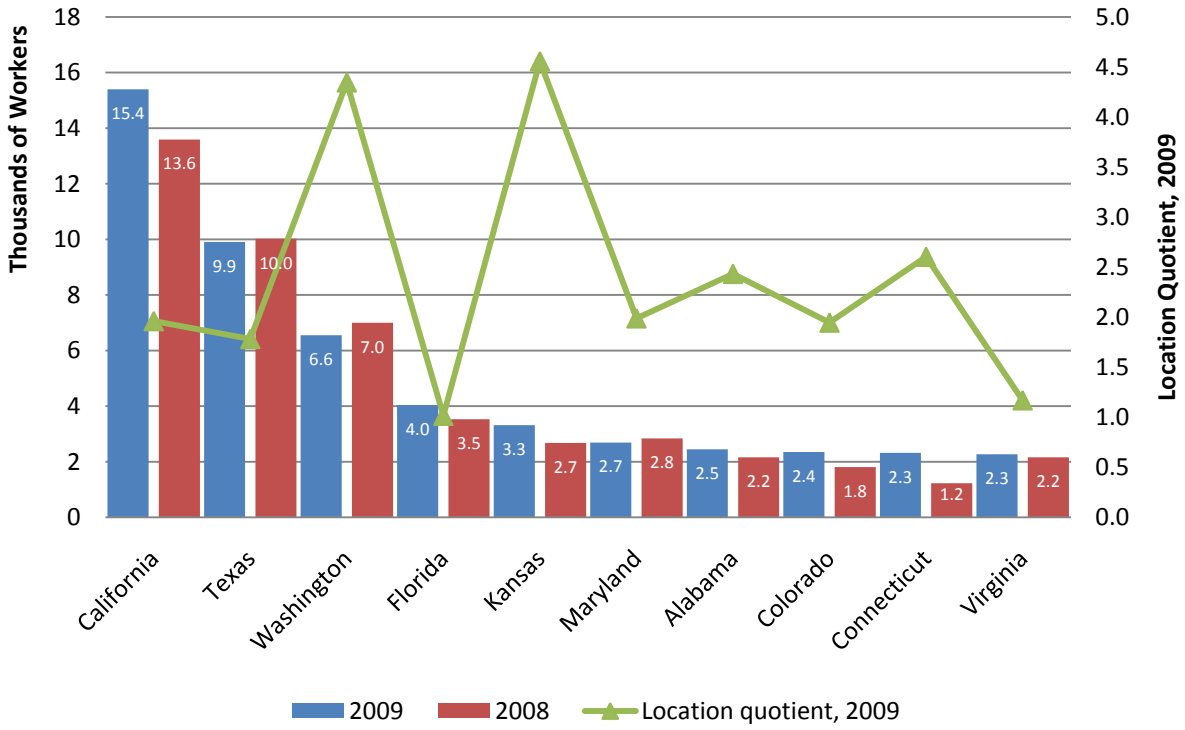
[1] Washington State Employment Security Department, Occupations-Industry Matrices, 2009 Q2

Table 1. Washington Employment in Selected Occupations Critical to the Aerospace Industry, 2008-2009…

Occupation Title	2009	2008	Change from 2008 to 2009 (#jobs)
Logisticians	4,040	4,000	40
Aircraft Mechanics and Service Technicians	4,140	4,180	-40
Industrial Engineers	4,970	5,270	-300
Machinists	5,090	5,530	-440
Mechanical Engineers	5,920	6,170	-250
Aerospace Engineers	6,550	7,000	-450
Engineers, All Other	7,310	6,910	400
Inspectors, Testers, Sorters, Samplers, and Weighers	7,680	8,190	-510
Computer Specialists, All Other	7,800	7,530	270
Purchasing Agents, Except Wholesale, Retail, and Farm Products	8,120	8,060	60
Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	10,550	11,380	-830
First-Line Supervisors/Managers of Production and Operating Workers	10,550	11,380	-830
Management Analysts	11,750	11,240	510
Shipping, Receiving, and Traffic Clerks	16,640	17,680	-1,040
Computer Software Engineers, Applications	24,010	25,750	-1,740
Engineering Technicians, Except Drafters, All Other	3,250	3,140	110
Computer-Controlled Machine Tool Operators, Metal and Plastic	3,050	3,270	-220
Mechanical Drafters	1,990	2,130	-140
Materials Engineers	1,400	1,380	20

Data source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics

Figure 2. Aerospace Engineers by State

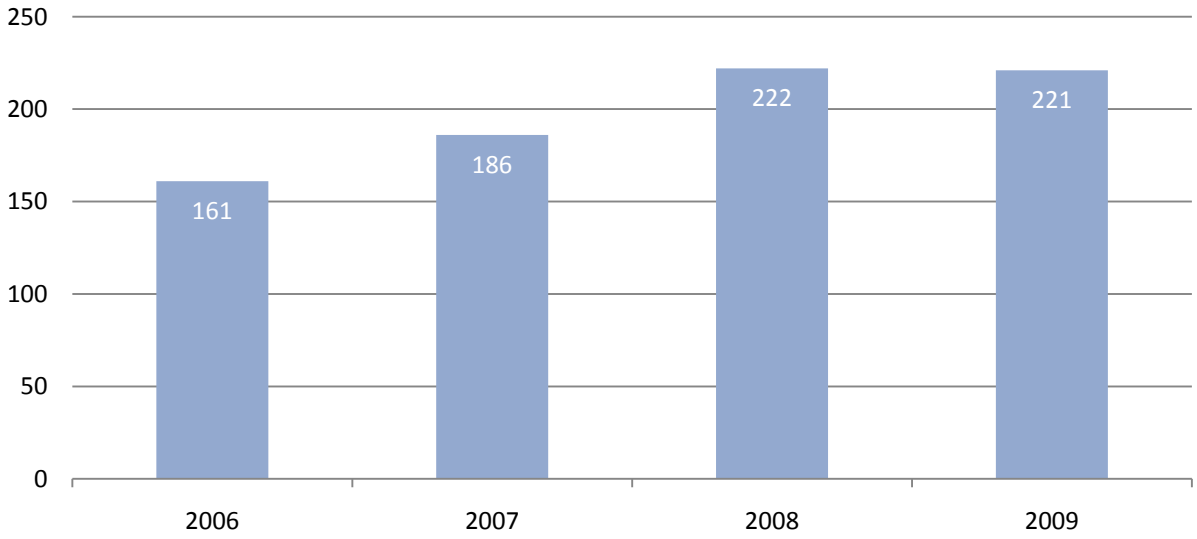


Data source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics

B&O Tax Incentive

In 2009 (most recently available year), 221 Washington state companies took advantage of the aerospace B&O tax incentive (**Figure 3**). However, this is far less than the estimated 650 companies that are either aerospace companies by definition (NAICS) or do significant aerospace-related work. This number is based on accountability reports submitted to the Washington State Department of Revenue (DOR) by firms that claimed to have participated in aerospace tax incentives during 2009 calendar year. Participants in this tax incentive program reported over 77,000 employees in total, with 76% coming from Boeing.

Figure 3. Washington State Firms Taking Advantage of B&O Tax Incentive



Data source: Washington State Department of Revenue

Aerospace in Washington – The Industry Perspective

Washington is a world leader in aerospace. But Washington companies face an evolving competitive landscape and must be vigilant in working to continuously improve its long-term competitive position in a sustainable way.

A dynamic and growing industry. Between now and 2030, commercial aviation will continue to be a robust and growing industry of significant proportions. During that 20-year time frame, the market for commercial airplanes will total $3.6 trillion.

A changing competitive landscape. New entrants in a number of markets are changing the competitive landscape for Washington aerospace companies. To compete, aerospace companies in Washington must solve a dual challenge. First, they must continually develop industry-leading technology, which requires a robust pipeline of well-educated people to develop and apply these technologies. At the same time, they must build current and future products on a cost-effective basis.

Washington's competitiveness imperative. Because of this simultaneous need to gain maximum efficiency while investing in the future, the needs of aerospace are twofold.

1. Washington must help to drive costs out of the system in any way possible. This includes finding ways to reform state-run systems such as workers compensation to keep employer and administrative costs down while protecting injured workers.
2. Washington must invest in its own future, by giving current and future students the skills they need to compete in this dynamic, hyper-competitive industry. Engineers & technical workers will drive the success of this industry – and the states in which it operates – for many years to come. Washington must invest heavily in these fields of education in order to retain its traditional status as the leading state for commercial aerospace.

POLICY RECOMMENDATIONS

In the course of its work this past year, the Council has reviewed the following specific policy and/or budget recommendations which we pass on for consideration by policy makers:

1. **Expand Engineering Education Capacity:** In July 2010, the Higher Education Coordinating Board in collaboration with the University of Washington and Washington State University presented information to the Aerospace Council on the importance of engineering education to the aerospace sector. The presentation laid out the business case for expanding engineering education to meet the current and future talent needs of Washington's aerospace companies.

   The HECB report said that that fixing the problem was straightforward and cost effective. A $5.0 million annual investment to increase engineering education capacity at UW and WSU would create 260 additional engineering FTE and 98 new degrees annually. The investment would cost the state about $51,000 per engineering degree produced. Because engineers earn more than other degree holders, the investment would return to the state over $61,000 in additional tax revenue (present value over 40 years) and a positive return on investment—without considering the additional value to the state of lowering industry recruitment costs and maintaining aerospace employment. See Appendix [**A**] for more details.

2. **Create a Center for Aerospace Technology Innovation:** The mission of the proposed new Center for Aerospace Technology Innovation would be to advance new technologies addressing innovative products in aviation, aerospace, and defense. It would fund projects at the state's research institutions (primarily UW and WSU) building on existing strengths in aerospace research and would encourage strong industry-academic partnerships. Projects would be selected based on expert review, both scientific and industrial, considering critical criteria such as technological innovation, potential for impact on product development, and financial leverage by means of corporate support and/or grants from government or non-profit agencies. The Center would have minimal staff, just sufficient to facilitate rigorous decision making and timely management of awards, and would be overseen by an executive board with membership from state research institutions, the aerospace industry, and state government. State support at the level of $3 million per year, $6 million per biennium, is required to provide the breadth of programs needed to stimulate technology innovation in Washington's aerospace industry. The Center would report biennially to those committees of the Legislature concerned with economic development, summarizing its work, providing indicators of its impact, and outlining ideas for enhancing benefits to the State. See Appendix [**B**] for more details.

3. **Tax Credit for Aerospace Apprenticeships:** In 2008, the Washington State Legislature provided funding to develop training programs, in the form of apprenticeships, to ensure that the knowledge and skills of Washington's aerospace master trades people are passed on to the next generation of employees. Apprenticeships combine on-the-job training with classroom instruction, allowing a student worker to earn a living wage while achieving continued growth in their occupation as well as a college degree. The Aerospace Joint

Apprenticeship Committee (AJAC) and its apprenticeship programs are a vital connection between education, workforce and economic development in Washington.

Currently, 15 US states, are offering tax incentives to businesses with apprenticeship programs as a means to create new jobs and stimulate the economy. Most of the states provide a variation of a five thousand dollar tax incentive to employers for each new apprentice hired. According to a survey that AJAC conducted in October 2010 of Washington manufacturing employers, 71.4% of respondents said they would consider hiring one or more apprentices for the program, who they would not have otherwise hired, if they received a $5,000 tax credit for each new apprentice. To stimulate re-hiring and create jobs for Washington residents, AJAC proposes a $5,000 tax incentive for employers who hire an Unemployment Insurance (UI) participant as a registered apprentice with the AJAC. See Appendix [**C**] for more details.

4. **Industry Association Recommendations:** The industry associations in the state (AFA, PNAA, INWAC and PNDC) have a number of priorities for the upcoming legislative session including business climate reform (worker's comp and UI), enabling more students to attend the recently established Aerospace Training and Research Center, tax policy recommendations and research and marketing recommendations. See Appendix **[D]** for more details.

2010 AEROSPACE COUNCIL WORK PLAN OVERVIEW AND PROGRESS

Early in 2010, the council created a work plan to guide our meetings organized in each of its three focus areas. Below is a review of that work plan, progress in 2010 and action items for 2011, if any.

ECONOMIC DEVELOPMENT (OPPORTUNITIES LISTED IN ORDER OF COUNCIL PRIORITY):

1. **U.S. Air Force Tanker**

   Overview: The Governor created a coalition of industry leaders (Washington Aerospace Partnership) to help generate support for Boeing's bid to manufacture and assemble a replacement for the KC-135 Air Force Tanker, which would be based on the 767. The goal is to get the political roots as strong as possible not just here in Washington but in the 14 other states that are relevant to the tanker. We have a number of companies throughout the state who are involved in constructing and maintaining the 767. A 2010 Boeing-funded study by the American Enterprise Institute estimates that a Boeing win would create between 62,605 and 70,706 U.S. job-years over the life of the contract, of which many would be in Washington.

   Actions Taken in 2010:
   - The Washington Aerospace Partnership, a non-profit grassroots organization committed to advocating for the tanker in Washington, updated the Council on their work.

   Action Items for 2011:
   - Continue monitoring developments and reacting as appropriate until a final decision is made.

2. **Aerospace Company Recruitment**

   Overview: The goal is to strengthen our existing aerospace supply chain by recruiting companies into Washington State that fill gaps in our local supply chain. In 2008-2009, the Snohomish County EDC developed a detailed aerospace supply chain gap analysis which is comprehensive and could provide a foundation for a broader state recruitment strategy.

   Actions Taken in 2010:
   - At the May 11, 2010 meeting, Commerce, Snohomish EDC, AFA Board members and Aerospace Council members discussed how to make the Snohomish County study available to the Council and to ensure Snohomish EDC participation going forward. The discussions were positive and a dialogue continues among these stakeholders. The Departure of the Snohomish EDC Director this Fall has delayed a final agreement here.
   - Commerce Director Weed attended the AeroMart supplier conference in Toulouse, France and met with six European aerospace companies to discuss potential investment in Washington.

Action Items for 2011:

- Develop an action plan that allows the Governor/Department of Commerce to identify potential recruitment targets to round out the supply chain within the state, using EDC expertise and relationships.
- A recruitment strategy will be used to target potential meetings for the Governor and Commerce at the Paris Air Show in 2011.
- Washington will host five foreign delegations in February for the Pacific Northwest Aerospace Alliance Annual Conference and have the opportunity to present the business case for investing in Washington.

3. International Trade

Overview: Connecting Washington's supply chain to other original equipment manufacturers (OEMs) and tier I suppliers is critical to the industry's vitality. In 2010, Commerce has considerably expanded its international trade program. With 2 FTEs in Seattle and several foreign consultants that focus on aerospace, Commerce's goal is to help companies gain access to global supply chains through research, contracts and marketing. Programs include local seminars, international business development missions and foreign trade shows.

Actions Taken in 2010:

- The Governor led a trade mission to China in September and promoted Washington State aerospace supply chain companies.
- 14 companies participated in Commerce-led international trade missions to three target aerospace markets: Montreal (April), China (November), and France (December).
- Commerce delivered 208 trade assistance cases for more than 100 individual aerospace companies.

Actions Items for 2011:

- Organize two local supplier fairs and trade shows that bring OEMs and Tier 1 suppliers to Washington State.
- Coordinate with local industry organizations, including AFA, PNAA and INWAC, to develop a domestic marketing strategy for Washington State aerospace. Commerce's focus has been on international marketing and business development, but there is a need for better coordinated marketing within the US.
- Commerce will lead a delegation of aerospace companies and suppliers to the Paris Air Show in June 2011.

4. Unmanned aerial vehicles (UAVs)

Overview: The unmanned systems industry is expected to experience impressive growth over the next few decades and could be a major driver of job growth in the aerospace sector. Washington's UAV activity is primarily related to Boeing, which acquired Insitu in 2009,

and is heavily concentrated in the Columbia River gorge, Vancouver and Puget Sound areas. The complex technology and software that support UAVs are a potential high value sub-sector for the state. Market barriers for the unmanned sector include the high cost of civil applications of UAVs and current FAA restrictions on the use of national airspace.

Actions Taken in 2010:

- The council convened a special meeting in July to discuss the UAV industry, including presentations by Commerce and the University of Washington.
- State officials have been actively engaged with Boeing/InSitu on a location decision for their planned new headquarters facility.

Actions Items for 2011:

- The Council will continue to investigate whether Oregon offers a more competitive business environment than Washington for UAV production and related activities.
- ***Policy Recommendation:*** Extend the current commercial aerospace tax incentives to cover the design and manufacture of all aircraft, both commercial and military, to help grow burgeoning UAV-related operations in the state.

5. **Aerospace Software**

Overview: This will be an agenda item for the first meeting of 2011. There has already been some overlap between information and communication technology (ICT) and aerospace, such as the Performance-Based Navigation (PNB) solutions developed by Kent-based Naverus, now part of GE Aviation. Aerospace is becoming increasingly software-intensive. For example, there are more than eight million lines of code in Boeing 787, compared with two million in the 777. Software will continue to play a larger role in the enabling infrastructure for aerospace companies – for management, technical and supply chain operations. As a state, we have a significant software skill base that may represent an opportunity to develop in this area.

Actions Taken in 2010:

- ***None***

Actions Items for 2011:

- Research and provide a report on potential opportunities for Washington in aerospace software and cross-industry collaboration between the aerospace and ICT sectors.

6. **Green Aviation**

Overview: Aviation has taken on carbon as one of their big issues. Carbon emissions are highly scrutinized, growing proportionally and are measurable. Sea-Tac Airport could be the first airport in the world to provide scalable aviation biofuels, which could happen as soon as 2013. Even though carbon is still not taxed in the U.S., carriers operating in Europe will soon need to comply with cap-and-trade carbon pricing. This will also be a theme of the 2011 Air Show in Paris, France.

Actions Taken in 2010:

- John Gardner of WSU updated the Council on the aviation biofuels initiative and key challenges and opportunities moving forward.

Action Items for 2011:

- Identify ways to support the research and development, manufacture, distribution and use of aviation bio-fuels in the Pacific Northwest.
- A recommendation is for the Council to work directly with the congressional delegation and let them know the importance of this opportunity.
- Make aviation biofuels a focus of the Paris Air Show and the Governor's Mission to Europe.

WORKFORCE TRAINING

1. Education and Training Coordination

Overview: The goal is to coordinate the state's mid-level aerospace education and training programs through the State Board for Community and Technical Colleges (SBCTC). Key organizations in this initiative with the community and technical colleges include the Center of Excellence in Aerospace and Advanced Manufacturing at Everett Community College, the Washington Aerospace Training and Research Center at Edmonds Community College, the emerging Inland Center for Aerospace Training at Spokane Community College, and AJAC, the Aerospace Joint Apprenticeship Committee. A great deal of progress has been made this year in establishing systems for coordination and collaboration.

Actions Taken in 2010:

- Community and technical colleges offering aerospace programs, with technical assistance from the Center of Excellence, have formed a collaborative workgroup, the Aerospace Curricular Alignment Team (ACAT), to evaluate the state-wide platform of technical training, identify training gaps, and develop common curriculum that assists students in more seamless pathways to skill building, education and employment. This team includes twenty-two community and technical colleges, AJAC, and training managers from Boeing. Additional aerospace companies have been invited to participate on this team.
- Many colleges have inadequate equipment to provide state-of-the-art training. Fortunately, four aerospace colleges responded to a request for proposals from SBCTC and were awarded a total of $500,000 of the Governor's 10% WIA fund to purchase aerospace-related equipment.

College	Equipment
Bates Technical College	Machining equipment
Clover Park Technical College	Aviation training simulators
Renton Technical College	Five Axis Vertical Machining Center
South Seattle Community College	Aviation training simulators

The equipment has been installed and students and faculty are excited and appreciative of these new learning opportunities.

- Dr. Richard Strand, Dean at Olympia College, developed an inventory and measured production level of aerospace programs in the community and technical college system over the past ten years. He grouped aerospace workers into five key industry clusters: Composite Manufacturing, Electronics, Industrial Manufacturing Technology, Machine Tool Technology, and Aircraft/Airframe Mechanic. Dr. Strand's research showed that production of aerospace workers has softened over the past decade, but it is now on the increase and could be expanded rapidly with funding for additional capacity. This work is being used as a platform for further discussion among colleges to coordinate curriculum and course outcomes.
- Composite Manufacturing training was identified as a major gap in Dr. Strand's research. Current programs in composites are relatively small, and much of this production targets the marine industry. Colleges and Boeing are now discussing expansion of this program and adoption of Clover Park Technical College's model curriculum. Colleges have convened several times to discuss sharing curriculum in composites and identifying equipment requirements. They also have been meeting with AJAC, who is adding composite manufacture equipment to their mobile training unit.
- The Aerospace Joint Apprenticeship Committee has so far created collaboration between 4 community and technical colleges to offer uniform apprenticeship programs across the state with common courses and course numbering to provide transferability and standardization.

Action Items for 2011:

- Continue identifying specific ways to help increase the coordination, articulation, and growth of aerospace training programs state-wide.
- Continue to support collaborative groups such as ACAT; invite additional industry representatives.
- Seek funding to provide capacity to train needed aerospace workers.
- AJAC is organizing the effort to showcase Washington's aerospace and education training programs in a unified manner at the Paris Air Show.
- Spokane Community College and AJAC are coordinating the aerospace training and education programs to secure additional funding through the Trade Adjustment Assistance Community College and Career Training Grant.

2. Develop Industry Driven Training

Overview: It is critical to build program capacity at the Washington Aerospace Training and Research Center in Snohomish County, the Spokane Aerospace Technology Center in Spokane and the Aerospace Joint Apprenticeship program to develop and provide industry-driven, mid-level training to new students and current workers. Building degree and certificate programs at the community and technical colleges is also an important aspect of this activity.

Actions Taken in 2010:

- The ACAT team is working to insure that colleges' degree and certificate programs in aerospace meet industry standards. Together with Boeing training managers, AJAC, and both aerospace training centers, the team has scheduled five aerospace cluster workshops to review and revise core competencies critical to meeting industry needs. These workshops will include faculty and trainers who can integrate industry needs into current and future curriculum for college degree and certificate programs, short-term incumbent worker training and apprenticeship opportunities.
- Aerospace training centers at Edmonds and Spokane community colleges were established in 2010 and are offering classes. The Washington Aerospace Technology and Resource Center (WATR Center) has moved into their facility at Paine Field and is offering classes. The WATR Center is sharing curriculum with the Inland Northwest Aerospace Technology Center in Spokane. The Spokane center is offering classes at their current facility and is working with the Spokane Airport, Triumph Industries, and AJAC to develop plans for a new facility near the airport.
- The Aerospace Joint Apprenticeship Committee (AJAC) has worked with industry subject matter experts to develop innovative apprenticeships incorporating latest technology, safety and best practices. AJAC is partnering with approximately 60 participating employers and growing.

Action Items for 2011:

- Continue collaboration between WATR Center and Spokane Community College to offer training state-wide.
- Continue to pursue development of Spokane Aerospace Technology Center facilities. Encourage and seek industry participation in curriculum and program development efforts.
- Support continued activities of ACAT to revise short and long-term curricula to meet new industry requirements.
- AJAC will offer training to employers across the State by bringing the Advanced Inspection and Manufacturing Mobile Training Unit (AIM-MTU) to their door. The AIM-MTU is utilizing industry subject matter experts to create modularized curriculum and to bring the most advanced technology and short term training directly to employers.

3. Create clear educational pathways, increase transfer agreements between educational institutions, and award credit for student's prior learning.

Overview: Post-secondary pathways and career advancement opportunities for future and current aerospace employees must be clear and accessible. Pathways should lead from two-year to four-year aerospace degree programs to shorten the time to degree completion. Curriculum must be flexible to meet the changing demands of industry and to meet the time constraints of working adults.

Actions Taken in 2010:

- Five colleges offering FAA certified Airframe and Power Plant Mechanic programs have collaborated with AJAC to develop a high quality common curriculum that is

currently under review for FAA certification. This curriculum has been developed with common course numbers so that students can transfer credits earned in technical courses easily from one institution to the other and employers can clearly understand the competencies included in each course. Common course numbering is a convention now common in academic transfer courses in Washington State, but is more difficult to apply to technical courses because of their specificity and the much larger number of technical courses offered related to technical occupations. The Airframe and Power Plant common courses are the first technical common courses in our state system.

- Washington's 2-year colleges are working toward aligning and standardizing aerospace curriculum which will allow course content to be updated and deployed regularly and system-wide as industry needs change.
- Creation of aerospace apprenticeship programs with full college credit allowing apprentices to acquire a two year degree and transfer to a four-year degree program.
- Progress is being made in common curriculum, technology transfer, and articulation among training programs.

Action Items for 2011:

- Complete recommendations for credit for prior learning in aerospace occupations.
- Establish common course numbering and curriculum for all Aviation Maintenance Technology programs (A & P) in the community and technical college system. AJAC will continue to lead the coordination of the five A & P schools in developing common curriculum, which provides greater transferability and accessibility for these programs.
- AJAC, King County WDC, and South Seattle Community College have created and are implementing an industry driven 10 week pre-apprenticeship training. The program includes a post training internship creating a pool of qualified candidates with entry level skills and certification for aerospace employers.
- Identify next steps and begin pursuing a crosswalk of certifications and skills for veterans transitioning into civilian aerospace jobs.

4. Engage business and labor to identify training requirements leading to new credentials requiring less than two years to complete.

Overview: Community and Technical Colleges are currently expanding program production to meet Boeing's demand. Production of aerospace workers had fallen off during the post 9/11 recession and aerospace downturn, but production of skilled workers is increasing now. Increased program capacity among the colleges is available (if funded). However, knowledge gaps remain between business and labor requirements and training offered.

Actions Taken in 2010:

- The Aerospace Joint Apprenticeship Committee (AJAC) has played a key role in developing opportunities for potential workers and training for incumbent workers. Collaboration efforts between Boeing, community and technical colleges, and AJAC have identified two training programs: Advanced Composites and European Aviation Safety Agency (EASA) Aviation Maintenance Technician Certification where there are gaps between training and employment needs.

- Dr. Dirk Weiss of the Washington Technology Center has joined the team and is developing protocols for transferring research on composite materials into aerospace training curriculum. He meets regularly with college faculty and other researchers.
- Working closely with the aerospace industry, ACAT has identified Composite Manufacturing as one of five industry clusters for collaborative curriculum transfer. The Aerospace Curriculum Alignment Team will bring faculty together to work on developing common curriculum, integrating the principles of Dr. Weiss's research transfer protocol, and developing appropriate career pathways for students and workers involved in this program.
- Employees with European Aviation Safety Agency Aviation Maintenance Technician (EASA) Certification are needed by European companies that fly Boeing airplanes. This training is not currently available in the United States. It will take some time to develop the certification program here, but the colleges are working with AJAC to determine how best to implement this training in Washington.

Action Items for 2011:

- Create training that is responsive to dynamic employer and industry needs;
- Work with Washington Technology Center and aerospace community and technical colleges to transfer composite research into curriculum;
- Begin identifying resources and next steps for European Aviation Safety Agency (EASA) Aviation Maintenance Technician certification training.

5. Aging Workforce

Overview: There is a need to address the challenges of employee attrition due to the aging aerospace workforce through development of: 1.) mentorship and training opportunities between new and experienced employees; and 2.) targeted marketing strategies to recruit individuals leaving the military, women, skilled dislocated workers from other industries, and other under-represented groups.

Actions Taken in 2010:

- The Aviation High School, Museum of Flight, school district skills centers, the Center of Excellence in Aerospace and Workforce Development Councils are all working on strategies to attract youth to aerospace careers.
- AJAC offers programs to transfer knowledge between generations. They recruit for employers and connect them with the next generation of diverse workers.
- The Museum of Flight partnered with Employment Security and Workforce Development Councils to offer the Washington Aerospace Scholars opportunity to Workforce Investment Act eligible youth. A total of 157 students completed an online and resident program in Seattle during summer 2010.
- Spokane Community College, the Museum of Flight, the Spokane Area Skills Center, and the Workforce Development Council worked together to sponsor a summer aerospace academy in Spokane.

Action Items for 2011:

- Increase aerospace career exploration opportunities for middle and high school students.
- AJAC is looking to bring more women and minorities into to the industry and to expand their Veterans in Aerospace program considerably in the future.
- AJAC is continuing to build their Train the Trainer program to teach the aging workforce how to pass on their skills and knowledge to the next generation of employees.

6. Develop Mentorship and Training Strategies

Overview: There are a number of incumbent workforce issues. More "train-the-trainer" and "teach-the-teacher" programs are critical. There needs to be an ongoing partnership between legislators, business, education and the aerospace council to accomplish this.

Actions Taken in 2010:

- Aerospace instructor programs and train-the-trainer are available. An applied baccalaureate is in the planning for the future.
- Airframe and Powerplant Program Alignment—The five community and technical colleges in WA that do this training have worked with AJAC to develop a common FAA-approved Airframe and Powerplant curriculum The curriculum has been developed and FAA approval is in process.
- After research, AJAC discovered that 15 other states have implemented employer incentives for apprenticeship programs. Most have started with a $2,500 incentive (each employer they bring on they will receive approximately $2,500). Those programs have been so successful that the majority of the states have upped them to $5,000. From the October 2010 AJAC Survey Results regarding apprenticeship incentives in Washington, the overwhelming response received was "yes," employers would bring on employees if they were offered a tax incentive similar to this.

Action Items for 2011:

- AJAC Inspection and Manufacturing Mobile Training Unit Program will be online in January 2011.
- Dr. Dirk Weiss of the Washington Technology Center and the Aerospace Curriculum Alignment team have scheduled a train-the-trainer event for faculty to learn about recent research transfers in March 2011. College faculty and instructional deans statewide will be attending this train-the-trainer event.
- The council has a policy proposal to adopt the apprenticeship tax incentive described above.
- An applied Baccalaureate (Teach Tech) is in the planning for the future.

7. Ensuring a strong, skilled aerospace workforce for the future. Develop coherent technical educational pathways to support aerospace workers long term career needs. Launch an outreach campaign to recruit middle school, high school, and college-age students highlighting careers in the aerospace industry. Maintain a web-based clearinghouse

to provide information on post-secondary aerospace training programs offered throughout the state.

Overview: The Center of Excellence aims to build a competitive workforce for aerospace and aviation in Washington State. There have been several outreach programs and successes. There are ten "Centers of Excellence" in the State, although not all focus on aerospace.

Actions Taken in 2010:

- There are several outreach activities to engage students including *Mother Daughter TEA*, *Flight of Innovation*, and *Get AMPT*.
    - The *Mother Daughter TEA* event was founded to encourage young women to take an interest in pursuing a career in the engineering industry.
    - *Flight of Innovation* education program uses a scenario-based immersive learning model that encourages students to become innovators and collaborate as a team.
    - *Get AMPT* helps students learn about the wide range of excellent opportunities available in advanced manufacturing in Aerospace and Marine career opportunities.

Action Items for 2011:

- Continue to convene the Aerospace College consortium of 18+ community and technical colleges to share information, collaborate on curriculum, and pursue joint projects.
- Continue to promote aerospace careers with youth and secondary schools.
- Continue to serve as a repository of aerospace curriculum and information.

8. Support third-party initiatives in the K-12 system directly focused on enhancing the foundational skills leading to higher education degree attainment in the science, technology, engineering, and math fields.

Overview: Washington STEM Center seeks to improve student achievement and opportunity in areas critical to our state's economic prosperity: Science, Technology, Engineering, and Mathematics (STEM). This builds upon existing programs, such as LASER and the Transitional Math Project. This initiative aims to catalyze innovation in the WA's K-12 education system, increase teacher effectiveness and student learning. Boeing was involved in a 2-year planning process to create the STEM center along with Microsoft, Battelle, the Paul G. Allen Foundation, and the Bill & Melinda Gates Foundation.

Actions Taken in 2010:

- Council was briefed on efforts in this area.

Action Items for 2011:

- Beginning in January 2011, the Sno-Isle Technical Skills Center (one of 12 technical skill centers in WA), will be offering an Aircraft Assembly and Service Technician course. The course is designed to provide students with basic knowledge that would assist them in qualifying for entry level aircraft mechanic positions. It will also

provide an articulation path to aerospace certificate programs at the Washington Aerospace Training and Research Center.

- Boeing will be a major partner in the development and implementation of the Aircraft Assembly and Service Technician curriculum by providing subject matter experts, guidance for curriculum development, and donations of critical tools and equipment. Expansion of the Aircraft Assembly and Service Technician program into additional skill centers in WA is planned for 2011.

9. Build a business case for expanding degree capacity in aerospace-related high demand fields of study.

Overview: Baccalaureate and advanced degree Engineers and scientists are a shortage in our state. We need to figure out how to close the gap between the supply and demand for engineers in the industry. WA's aerospace industry relies on engineering talent. That engineering talent is the catalyst for innovation and productivity in the aerospace industry. WA is turning away qualified engineers from programs because there is not enough capacity to enroll them. Expanding capacity to meet demand is necessary. See [Appendix A], "Aerospace engineers in short supply," report which looks at engineering and education capacity in WA and its importance to the aerospace industry. The report is a collaboration between the HECB, UW, WSU, SPEEA and Boeing.

Community and Technical college degree capacity in aerospace industries has declined since 2001 but is currently expanding to meet recent demand. If demand for technical aerospace workers increases (as Boeing is currently projecting), budgetary limitations will reduce the colleges' capacity to continue to expand these expensive technical programs.

Actions Taken in 2010:

- Community & technical colleges have a transfer function in engineering production and are working on improving student outcomes in mathematics in particular.
- Community & technical colleges capacity for education and training in composite technologies is very small, but could be expanded with funding.
- The HEC Board has developed a proposal to expand aerospace engineer capacity at our four year schools for consideration by the Governor and legislature [See Appendix A].

Action Items for 2011:

- Explain the benefits of the HEC Board proposal to the Governor and legislature.
- Develop next steps based on feedback from policy makers.

RESEARCH:

1. Information Clearinghouse

Overview: There is a need to help better connect the state's research activities with industry. By matching research faculty at higher education institutions with aerospace industry's needs, the private sector can take advantage of the cutting-edge aerospace-related research being done locally. Specific areas of interest are in composites and advanced materials,

robotics, aircraft design and manufacturing. A proposed "Information Clearinghouse" could be one solution -- and UW and WSU currently have 2 staff members exploring the idea.

Actions Taken in 2010:

- UW presented at the Governor's Aerospace Summit in October on how companies can engage with aerospace researchers at the University.

Actions Items for 2011:

- Initiate a pilot project which would fund 2 post-doctoral fellow (one each at UW and WSU) to collaboratively:
  - Identify industry needs and university research strengths.
  - Assess and communicate database/web page needs.
- Commerce will help UW and WSU's newly created "Industrial Liaisons" engage with private industry in order to facilitate more interaction between the research community and companies

2. Center for Aerospace Technology Innovation

Overview: Aerospace is a high tech industry driven by innovation, and therefore it can benefit from industry-academic partnerships which leverage federal funding for high-tech research. Our state's higher education institutions have extensive research programs that could help drive aerospace innovation and make our industry more competitive in the world economy. The proposed Center for Aerospace Technology Innovation would be a public-private partnership driven by industry needs to help translate research into commercialized products.

Actions Taken in 2010:

- UW and WSU presented a 3-page white paper proposing a Center for Aerospace Technology Innovation (See attached)

Actions Items for 2011:

- **Policy Recommendation**: State support at the level of $3 million per year, $6 million per biennium, to be budgeted to create the Center for Aerospace Technology Innovation.

[A.] AEROSPACE ENGINEERS IN SHORT SUPPLY

Aerospace engineers in short supply

Persistent funding gaps limit opportunity for students and increase firm costs

As one of our State's most important economic resources and one of its largest employers, the aerospace industry needs talented young engineers to maintain and further develop its world leadership position.

And yet hundreds of *qualified students* are being denied admission to aerospace and related engineering degree programs in Washington because our research universities do not have the funding needed to educate them.

The rate of current aerospace-related engineering degree production is out of synch with employer demand, and the aerospace engineering workforce is aging, two factors likely to increase supply gaps in the future and impose additional employee recruitment costs on the industry.

However, the good news is that Washington can pursue a clear and proven strategy to address this challenge: fund more engineering enrollments at the University of Washington and Washington State University.

With an annual economic impact of $36 billion and direct employment of 84,000 highly educated and skilled workers (263,000 if you include indirect and induced employment), Washington's aerospace industry is an economic powerhouse, one of four or five businesses and industries that continue to define the State's productive and creative capacity in the 21st century.

This vital economic engine creates thousands of additional jobs in related industries, many in high-paying fields requiring advanced education and training.

The industry's success is based on its sophisticated manufacturing design and development capability. The engineering and scientific talent that sustains the industry must be maintained and enhanced if the state hopes to preserve its world leadership position.

Aerospace workforce totals 84,000 workers

Washington's core aerospace industry directly employs more than 84,000 workers. [1] About 72,000 of these workers (86 percent) are employed by the Boeing Company. [2] The remaining 156 aircraft, engine, and major component manufacturing firms are much smaller by comparison.

About 179,000 additional jobs exist in businesses and industries indirectly related to aerospace. Among these are manufacturers of small parts used in larger aircraft components and professional service providers serving other industries as well as aerospace.

Professional engineers, computer and software specialists, and others with high levels of education make up a large portion of all direct aerospace employment according to data provided by the Washington Employment Security Department.

[1] Data provided to the HECB by the Washington Employment Security Department, LMEA Division.

[2] Boeing Company website: http://www.boeing.com/aboutus/employment/employment_table.html

Top aerospace occupations

The table at right shows aerospace employment categories with 1,000 or more workers.

Professional engineers and individuals in engineering-related jobs with high levels of education account for a substantial share of the state's top aerospace occupations.

In 2008, professional engineers, engineering technicians, and mechanical drafters accounted for *eight* of 25 of these employment categories and 21,000 jobs (one quarter of all core aerospace jobs).

Based on BLS entry training levels, the data show that:

- 44 percent of the jobs in major aerospace occupations require a bachelor's degree or higher;
- 32 percent require a mid-level credential (post-secondary degree, certificate, or apprenticeship); and
- 24 percent require less than mid-level preparation (high school diploma, work experience, and/or on-the-job training).

Table 1—Occupational Employment for the Aerospace Industry
Washington State, 2008, Q2
Occupations with more than 1,000 employees

Occupational Title	Estimated Employment	Entry Training Level (BLS)
Aircraft structure, surfaces, rigging & systems assemblers	9,591	Long-term OJT
Aerospace engineers	5,669	Bachelor's degree
Engineers, all other	4,721	Bachelor's degree
Management analysts	3,329	Bachelor's degree plus work experience
Industrial engineers	2,895	Bachelor's degree
Business operations specialists, all other	2,892	Bachelor's degree
Inspectors, testers, sorters, samplers & weighers	2,749	Moderate-term OJT
Shipping, receiving, & traffic clerks	2,317	Short-term OJT
Logisticians	2,142	#N/A
Aircraft mechanics & service technicians	1,977	Postsecondary vocational
Purchasing agents, except wholesale, retail & farm products	1,952	Bachelor's degree
Computer-controlled machine tool operators	1,929	Long-term OJT
Metal and plastic mechanical engineers	1,840	Bachelor's degree
Computer software engineers, applications	1,678	Bachelor's degree
Machinists	1,532	Long-term OJT
Computer specialists, all other	1,438	Postsecondary vocational
Mechanical drafters	1,302	Postsecondary vocational
Engineering technicians, except drafters, all other	1,230	Associate degree
First-line supervisors/managers of production & operating workers	1,198	Related work experience
Materials engineers	1,188	Bachelor's degree
Budget analysts	1,167	Bachelor's degree

Demand for engineers outpacing supply in Washington

Demand for engineers is outpacing supply in Washington, a trend expected to continue unless we begin to increase support for engineering education at the UW and WSU.

- Overall statewide engineering degree production increased at an average annual rate of only 1.3 percent between 2003 and 2009 (**See Table 2).**
- In 2007, Washington produced 982 aerospace-related engineering degrees to fill 2,312 aerospace-related engineering positions.
- The current 2010 estimate by EMSI is 2,014 new and replacement engineering jobs in Washington. This is down significantly from recent years but still well above the current production level of 1,375 baccalaureate and graduate engineering degrees (2009).
- There has been no growth in overall engineering degree production at the UW in the past 15 years. This has slowed average statewide degree production significantly. The UW produces more than 60 percent of all engineering degrees in the state each year.
- A 2009 joint agency analysis of supply and employer demand predicts that from 2011-2016 Washington's demand for all types of engineers will be nearly twice the current level of Washington-produced engineers receiving degrees and entering the labor force.[3]

[3] Higher Education Coordinating Board, State Board for Community and Technical Colleges, Workforce Training and Education Coordinating Board, "A Skilled and Educated Workforce." See http://www.hecb.wa.gov/news/documents/Skilled-EducatedWorkforce2009.pdf

Table 2—Engineering Degrees Awarded in Washington, 2003-2009							
	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Degrees Awarded	1,264	1,255	1,262	1,293	1,347	1,343	1,375
% Change year-to-year		-0.7%	0.6%	2.4%	4.1%	-0.3%	2.4%

Demand outpacing supply

The UW and WSU produce the greatest number of aerospace-related engineering degrees in Washington.

The UW is the only institution producing degrees in industrial and aerospace engineering, the two disciplines currently in highest demand by the aerospace industry. WSU has several programs that target aerospace careers in other engineering disciplines.

The UW and WSU, through its branch campuses in Tri-Cities and Vancouver produced 850 of the 982 aerospace-related engineering degrees granted in 2007, about 87 percent of the total.

Washington State is ranked third in the employment of aerospace engineers behind California and Texas. [4] But our degree production has been declining in comparison to other states. In 2009, we ranked 22nd among states in the aerospace engineering degrees, down from 15th in 2003. [5]

Table 3 (below) provides more data on the production of aerospace-related engineering degrees and job openings statewide for 2007.

Some improvement in engineering degree production is beginning to take place. In the 2007-09 biennium, UW and WSU received funding to expand math and science undergraduate enrollments in engineering and several other fields. Since then there has been about a seven percent increase in the number of students majoring in engineering in these institutions.

These data do not show how many engineering students actually enter the engineering workforce after earning their degrees in Washington. Some take jobs in other fields; some move to another state to work; and some remain in state to earn a graduate degree. All of these factors reduce the supply of available workers below the level of degree production.

Table 3—Aerospace-related engineering degrees and job openings in Washington by discipline, 2007

Institution	Level	Electrical, Electronics, Communication	Mechanical	Computer	Aerospace, Aeronautical, Astronautical	Industrial	Materials	Total
EWU	BS	2						**2**
	MS							
Gonzaga	BS	21	24					**45**
	MS							
PLU	BS			4				**4**
	MS							
St. Martins	BS		10					**10**
	MS							
SPU	BS	12		2				**14**
	MS							
Seattle U.	BS	18	21					**39**
	MS			18				**18**
UW Seattle	BS	176	89	62	44	32	29	**432**
	MS	39	40	64	36	14	3	**196**
Walla Walla	BS							
	MS							
WSU Pullman	BS	50	82	11			8	**151**
	MS	10	16				4	**30**
WSU Tri Cities	BS	6	7					**13**
	MS		1					**1**
WSU Vancouver	BS	New Program	25					
	MS		2					
Total	**BS**	**285**	**258**	**79**	**44**	**32**	**37**	**735**
	MS	**49**	**59**	**83**	**36**	**14**	**7**	**247**
Total Degrees		**334**	**315**	**161**	**80**	**46**		**982**

Note: Allocation of degree awards among WSU campuses is estimated based on course enrollments. Some engineering degrees may be transferrable across disciplines. *Computer hardware engineers only. SOURCE: HECB from IPEDS data and OFM Higher Education Report 2006-07. Job openings data from EMSI, Inc.

[4] Bureau of Labor Statistics, May 2009, see http://www.bls.gov/oew/current/oes172011.htm

[5] HECB analysis of NCES IPEDS data.

Boeing's aerospace workforce is aging

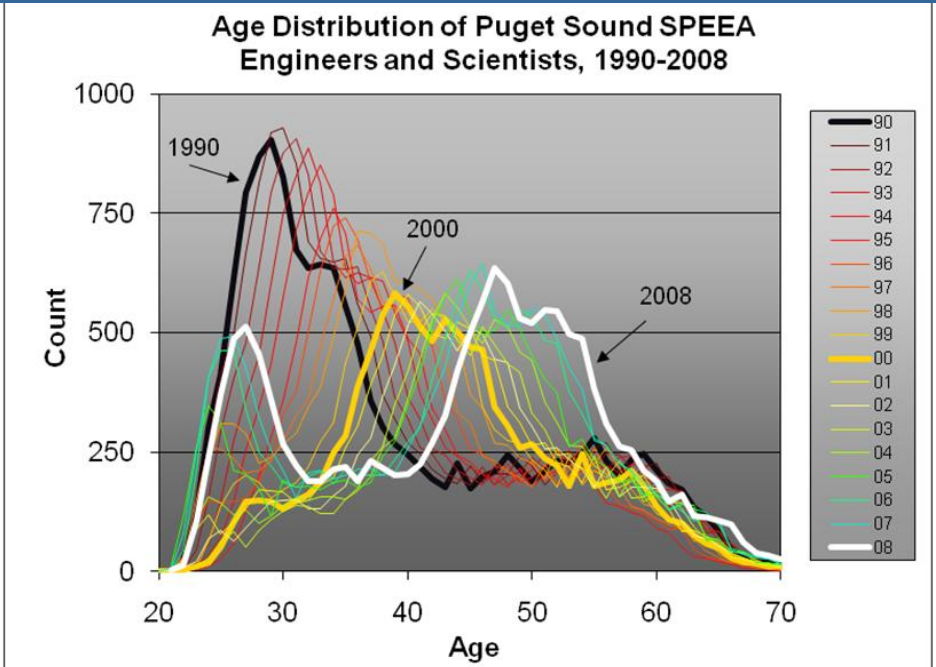
Boeing's engineering workforce is aging, another factor driving up demand for engineers in our state. Many Boeing engineers with more than 20 years of service will retire in the next decade and will need to be replaced with newly trained engineers.

The chart at right shows the changing age distribution of the Boeing engineering workforce based on data provided by the SPEEA union in Washington State.

More than 14,000 SPEEA engineers and scientists were represented in the Boeing Puget Sound bargaining unit in 2008.

Boeing employs about 20 percent of all engineers in Washington State. These engineers, who were in their 20s and 30s during the early 1990s, are advancing into middle age and are expected to begin retiring at increased rates in the next decade.

Table 4—Age Distribution of Puget Sound Engineers and Scientists



Source: SPEEA records from Boeing

Washington's reliance on importing talent may not be sustainable

Washington's aerospace industry has been forced to recruit engineers from other states and nations to meet its in-state supply gap. Much of this reliance on imported talent could be reduced if additional engineering enrollments were funded at the UW and WSU.

The alternative is to continue to fill high-paying aerospace engineering jobs with non-residents who have been educated elsewhere.

Analysis of H1B visa certifications shows that Washington employers applied for and received visa applications for 550 foreign engineers in 2009. Half of these were electrical engineers hired predominantly by communications companies. The total also included 68 mechanical engineers, 49 aeronautical engineers, and 29 industrial engineers. [6]

The Boeing Company applied for and received 40 applications in 2009 in Washington, including 16 aeronautical engineers and 10 engineers from other disciplines. These numbers were thought to be high considering the poor state of the economy in 2009.

An analysis of Census ACS data shows that in 2005, Washington experienced net in-migration of 2,290 workers with baccalaureate degrees or higher who identified their occupation as engineer. [7]

Presumably, most of these new Washington residents found employment in their field. The data was based on a survey conducted in a single year. Despite a high potential margin of error, the data is startling since it was nearly twice the level of in-state engineering degree production in 2005.

Washington's reliance on importing talent is well established….but is it sustainable? In 2008, the HECB convened an economic needs assessment work group co-chaired by Lee Huntsman (Life Sciences Discovery Fund) and Steve Van Ausdle (Walla Walla Community College).

The diverse panel of experts concluded that "our economy has increasingly relied on attracting specialized talent from outside the state [and] must instead produce a sufficient supply of its own skilled workers to meet its economic needs." [8]

[6] HECB analysis of U.S. Department of Labor data downloaded from http://www.flcdatacenter.com/CASE

[7] Spaulding, R. (2008), "Interstate Migration: Washington's Reliance on Imported Workers to Meet Employers' Human Resource Needs, Western Interstate Commission for Higher Education draft policy paper.

[8] See http://www.hecb.wa.gov/boardmtgs/documents/TAB1A.ENAWrkGroupReportv11.pdf

What needs to be done?

The easiest and least expensive way to increase the number of engineering degrees being attained by Washington residents is to fund new engineering enrollments at UW and WSU, where most of the existing engineering education capacity and infrastructure exists.

Traditionally, to spur more engineering degree attainment , the state has increased funded FTE enrollments in engineering programs.

These FTE appropriations have been added to the institutions' base funding and then carried forward on a permanent basis. In the 2008 and 2009 academic years, for example, the UW and WSU received new FTE funding to support enrollments in Science, Technology, Engineering and Mathematics (STEM) fields.

It costs the UW about $16,000 per year to educate one *undergraduate* FTE in engineering. The cost of educating one *graduate* FTE is $25,000 per year.

It takes about three undergraduate FTE to produce one undergraduate engineering degree (BS) because students are enrolled in different years, and a few students fail to complete. It takes 2.5 graduate FTE to produce one graduate degree (MS/PhD).

If we fund additional enrollments in engineering, will there be enough students waiting to take seats in engineering classes? The answer would appear to be a resounding yes!

In summer 2009 the UW was forced to deny admission to 370 of 880 **qualified** applicants to the College of Engineering.

These applicants were primarily students already attending the University of Washington or a Washington community or technical college.

They were all qualified for admission, but were denied due to a lack of program capacity. They included 60 women and 26 under-represented minority students.

What is worse, 42 percent of those not admitted (217 students) had applied for slots in aerospace, electrical, and mechanical engineering.

It would cost the state about $3.5 million per year to educate these students, an investment that would produce 72 additional aerospace-related engineers a year after the first class completed their degrees.

The UW has confirmed it has the capital infrastructure in place to accommodate the additional enrollment, but notes that further program expansion would require additional capital expenditure.

What needs to be done?

Although WSU had significant growth in the number of undergraduates seeking engineering degrees between 2004 and 2009, it now reports it is 'at enrollment capacity' in the fields of mechanical, civil, and chemical engineering.

Enrollment in these fields at the main and branch campuses grew 58% (from 499 to 789) during this period. This growth was attributed, in part, to a combination of new, high demand funding, increased student interest in engineering, and increased efforts in student retention.

We should note this level of growth is not sustainable, however. Budget cuts necessitating capacity limits in the current biennium forced WSU to deny certification to nearly 50 qualified engineering students. And WSU expects more than 80 qualified students will be denied admission in academic year 2010-2011. These students will have to find major fields other than engineering.

Given that funding for higher education is likely to be cut again in the next biennium, it is imperative now to begin advocating for appropriations that can help us reduce the engineer supply gap in Washington State. As a first step, the Washington Aerospace Council should consider endorsing a plan to support additional funding for the UW and WSU to expand enrollment in aerospace-related engineering disciplines.

An investment in the next biennium of $3.5 million would permit the UW to increase its undergraduate enrollment in aerospace-related engineering fields by 120 FTE and its graduate enrollment by 60 FTE. For WSU, an investment of $1.5 million would fund 55 undergraduate FTE and 25 graduate FTE.

This investment would produce about 70 additional degrees a year at the UW (46 bachelor's and 24 graduate) and 28 degrees at WSU (18 bachelor's and 10 graduate).

Table 5—Engineering Education Capacity Investment Plan

Proposed State Investment	**$ 5.0 million**
University of Washington	$3.5 million
Washington State University	$1.5 million
New Engineering Enrollments	**260 Additional FTE**
Baccalaureate	175 FTE
Graduate	85 FTE
New Additional Annual Engineering Degrees (beginning year 4)	**98 New Degrees**
Baccalaureate	64 Degrees
Graduate	34 Degrees
Annual State Cost Per Additional Degree (beginning year 4)	**$51,000**
Fiscal Return on Investment to State and Local Government [9]	**$61,400 per Degree**
Additional Annual Earnings (aerospace-related engineering median earnings minus Washington median baccalaureate earnings) [10]	$32,600 per degree
Annual Additional State and Local Tax Revenues (based on 9.5% average annual effective tax rate) [11]	$3,100 per degree
Present Value of Additional Taxes (over 40 years, 4.0% discount rate)	$61,400 per degree

[9] Calculation does not consider the additional potential benefit to state and local government of successfully retaining and growing Washington aerospace firms and related employment.
[10] Engineering earnings data from EMSI, Inc., and baccalaureate earnings from U.S. Census *American Communities Survey* data.
[11] Institute on Taxation and Economic Policy (2009) estimated WA state and local annual tax rate for taxpayers with incomes between $62,000 and $99,000.

For More Information
Contact John Lederer, Associate Director, Higher Education Coordinating Board
Tel: (360) 753-7822, Email: johnle@hecb.wa.gov.

[B.] CENTER FOR AEROSPACE TECHNOLOGY INNOVATION

Premises:

1. The aviation/aerospace industry is vital to Washington, both economically and in terms of the excellent, contributing citizens it supports.
2. It is a high tech industry dependent on continuing innovation.
3. As with other highly competitive industries (eg: agriculture, life sciences) there is a critical role for modest levels of state support directed at innovation.
4. In particular, enabling the strengths of the state's research universities to be brought to bear on new technologies that will drive the future of the aerospace industry is a highly leveraged way to advance the industry and its economic benefit to Washington.

Experience supports this approach:

1. There are numerous examples around the country showing that high tech industries benefit from industry-academic partnerships, leveraging federal research funding to provide fundamental research advances. However, additional funding and industry partnerships are needed for focused efforts to translate basic research into products.
2. University-company partnerships are highly effective because: a) academic labs can undertake technology innovation that is too risky or long-term for corporate entities; b) it is often possible to leverage additional financial resources from federal granting agencies and others; and c) universities provide highly trained individuals who can move, with the new technologies, to the companies.
3. The Boeing Company and other Washington firms have been active in supporting academic research in Washington and in translating that research into products. The Boeing Company has supported collaborative research efforts between UW and WSU, as well as individual investigator projects at these institutions separately. While this research has touched on several topics, projects are often incremental because of the short-term nature of funding. The proposed center will facilitate longer term funding, which will pave the way for a more comprehensive and forward-looking research agenda with a broader technology reach for the state's aerospace industry.
4. Several Washington companies have teamed with academic colleagues in successfully competing for funding from federal sources. One example is the FAA-sponsored AMTAS (Advanced Materials in Transport Aircraft Structures) consortium drawing together the expertise of five universities and a dozen private industry firms. In some cases, teaming has led to collaborations that bring in partners from other industries.

Research Strengths in Washington universities:

The University of Washington and Washington State University have established leading-edge capabilities in several technological areas that can help drive innovation in the aerospace industry for both commercial and defense systems. Examples include:

- Biofuels for jet engines. Most roadmaps indicate scaling a biofuel for aviation first from existing vegetable oils, to next generation bio-oil feedstocks (such as algae), to lignocellulosic biomass over the next ten years.
- Structural foams. New foams promise dramatic savings in both raw materials and weight, leading to improved fuel economy. Immediate applications in the aerospace industry are in replacing the seat foams as well as the fuselage insulation, but there are benefits to other industries as well.

- Aircraft life-cycle management. Interdependencies of new developments (e.g. the effects of reducing weight using new composites and biofuels) on subsystem performance (fuel burn, noise, aircraft recycling) drive system-level sustainability and offer leverage points for improvements through life cycle assessment.
- Composite materials. Composite materials offer the potential to increase the strength of materials used in aircraft manufacture while increasing fuel economy. Research at the two universities covers development of new materials, fabrication, and inspection.
- Novel functional materials. New materials support new devices and offer the potential for energy harvesting, new fabrication methods, etc.
- Nanophotonic devices for computing and communication. Nanophotonics is a critical technology to reduce cost and weight of electronics, as well as increase speed and reliability. The Microfabrication Lab and Nanotech User Facility at UW together provide an extensive array of fabrication, process and characterization facilities that is one of 13 sites in the National Science Foundation's National Nanotech Infrastructure Network.
- Secure networking. Networking plays an important role in the design of hybrid aircraft power systems, which involve distributed energy resources, and wireless technology leads to savings on fuel and assembly costs, as well as new business models for in-flight services. However, security needs in aerospace applications are high.
- Unmanned vehicles. One of the fastest growing sectors in the aerospace industry is unmanned aerial vehicles (UAV). Research in dynamic and networked systems, founded on control theory, as well as bio-inspired flight is critical for UAV innovation.
- New materials for ice prevention. New coating materials prevent the formation of ice by altering the surface tension without adding significant weight to the aircraft, addressing one of the most serious safety hazards in the aerospace industry.

Plan:
Building on this experience that demonstrates state institutions can be a major support to innovation-dependent industries, the proposal is to establish the

Center for Aerospace Technology Innovation:
The mission of the Center will be to advance research on new technologies that offer the promise of innovative products in aviation, aerospace, and defense.

Approach:
- The Center will act primarily as a funding source to support research at the University of Washington and Washington State University.
- It will use expert review, both scientific and industrial, to evaluate research proposals and make awards.
- Among the criteria considered will be technological innovation, potential for impact on product development, and financial leverage by means of corporate support and/or grants from government or non-profit agencies.
- The Center will seek to enhance its impact by soliciting corporate support and aiming to make awards to projects that have potential for follow-on funding from other sources.

Structure:

- The Center will be overseen by an executive board consisting of five members – a University of Washington representative, a Washington State University representative, a Boeing representative, a representative of aviation industry, and a person chosen by the Governor to represent the economic development interests of the State.
- The Center will have minimal staff, just sufficient to facilitate rigorous decision making and timely management of awards.
- The Center will solicit the interest of units within the two research universities – departments, institutes, etc. – and establish Center membership criteria whereby such units can be pre-qualified as potential recipients of Center awards, thus simplifying award management.

Operations:

- The Center will establish mechanisms for soliciting and evaluating proposals and for making awards and reporting on technological progress, financial leverage, and other measures of impact.
- Among those mechanisms will be a Selections Committee charged with choosing awardees; this committee will be made up of half academic researchers and half corporate representatives who have decision making authority for technology choices in their firms.
- The University of Washington will be asked to provide administrative infrastructure for the Center.

Funding:

- State support at the level of $3 million per year, $6 million per biennium, will be budgeted.
- Additional support will be solicited from companies, foundations and donors.
- Beyond possible donations, the Center will seek to leverage its financial impact through joint support arrangements on a project-by-project basis as appropriate.
- The two universities will limit indirect cost charges on awards to administrative costs, foregoing facilities costs, provided the research is done in facilities supported by state operations and maintenance funds.

Reporting:

- The Center will report biennially to those committees of the Legislature concerned with economic development, summarizing its work, providing indicators of its impact, and outlining ideas for enhancing benefits to the State.

[C.] AJAC – BUSINESS TAX CREDIT FOR APPRENTICESHIP USE IN WORK FORCE

In 2008, the Washington State Legislature provided funding to develop training programs, in the form of apprenticeships, to ensure that the knowledge and skills of Washington's aerospace master tradespeople is passed on to the next generations of workers. Apprenticeships are unique in that they combine on the job training with classroom instruction, allowing a student worker to earn a living wage while achieving continued growth in their occupation while simultaneously working towards their college degree. The Aerospace Joint Apprenticeship Committee (AJAC) and its apprenticeship programs provide the vital connection between education, workforce and economic development in Washington.

AJAC is unique. AJAC is bipartisan. It works with both union and non-union businesses in the aerospace industry. AJAC is a statewide program, currently running in Pierce, Spokane, King, and Snohomish Counties with offices in both Seattle and Spokane. Plans to increase outreach operations in the coming months include the use of a mobile training unit designed to travel throughout the state to provide instruction and hands on training in rural areas. AJAC's main goal is to support and train the next generation of workers. Each apprentice works during the day and theoretically engages in class instruction at a community/technical college or designated training center in the evening. AJAC is a pathway. All course credit earned is transferrable to other colleges and can be applied to a 2 year and/or 4 year degree program. (Many other apprenticeship programs are dead degrees and don't provide this quality.) As well, apprentices are earning wages while they are working. They are NOT on Unemployment Insurance (UI), they DO have healthcare and do NOT utilize other government catch programs as a result. AJAC works to transition people from UI, putting them to work. AJAC is aware of the difficulty employers are having finding skilled workers. The apprenticeship program has the ability to help employers fill their needs. *(To be clear, AJAC does NOT hire. If asked, AJAC will share their pool of resumes for those who have passed qualifying requirements and completed instruction.)* Lastly, training in the aerospace manufacturing and mechanic trades includes the highest level precision work. With this high level of training the apprentice can transfer their work skills to other industry sectors (marine, biomedical, etc) but the same is not so when trained in other disciplines. Training students to the highest level possible provides flexibility in the work force. This is invaluable in the trades.

Although the aerospace industry is the economic driver in WA, baby boomers are retiring and unless WA has a skilled, trained workforce to replace them, their secrets will retire with them.

Tax credits for businesses hiring apprentices who have completed a certified apprenticeship program have been successful in 15+ other states and many countries around the world. It is helping to create new jobs and stimulate the economy. According to a survey conducted by AJAC in October, 2010 asking Washington manufacturing employers for their response; 71.4% of respondents said they would consider hiring one or more apprentices at their site (while they would not have otherwise hired them) – IF a $5,000 tax credit incentive was available for each new apprentice hired. In most states offering the tax credit, the sum of money is divided into payments. The tax credit is a Single Business Tax Credit with money delivery in a bifurcating disbursement; first and foremost covering the costs of tuition and books. The remaining balance is to be used as

discretionary funds for wage-related costs including salary, fringe benefits and other payroll expenses. The tax credit is intended to offset the direct and indirect costs of establishing the registered apprenticeship program. If an employer earns an apprenticeship tax credit in a year that they report no business income, the unused tax credit can be carried over to the next taxable year.

Eligibility requirements require the apprentice to be in a Washington State Registered apprenticeship program. The program cannot be less than 2,000 hours and must provide an onsite mentor to the apprentice to ensure that they cross train and fulfill the requirements of the program. They learn skills from masters in their field. Apprenticeship terms are occupation specific. The average term is four years (for journeyperson status), although apprentices may serve for a two-year time period and decide to exit the program. The apprentice must be employed full time. Pre-apprentices are not counted as apprenticeships and are not eligible. Successful completion of the registered Apprenticeship Program earns the apprentice nationally recognized state certification as a journeyperson with transferable academic credits that provide a pathway to further higher education if desired.

The goal of the proposed tax credit is to provide assistance in the form of an incentive to employers that hire registered apprentices at their site. The tax credit is designed to help offset costs as businesses recover from the recent economic downturn. The credit works to stimulate re-hiring and create new jobs for Washington residents. Washington State legislators have shown interest in supporting apprenticeships in the manufacturing and industrial sector. They recognize the need to support the trades and help their constituents re-enter the job market. Despite the current budget constrictions, the need to help jumpstart the system so that it can return to its potential is now. Businesses make a powerful statement taking on apprentices and training the next generation of aerospace workforce in WA State. With nearly half of all workforce vacancies in the next decade likely to demand serious occupational skills acquired with a combination of postsecondary courses and learning on the job, apprenticeship programs are at a great advantage. ***AJAC and their apprenticeship program connects employers and work seekers in WA State to create jobs that lead to sustainable futures.*** Legislation is currently being drafted introduced, discussed and analyzed by policymakers in their Committees during the upcoming session.

Current Status: Pending

[D.] INDUSTRY ASSOCIATION RECOMMENDATIONS

December 16, 2010

RECEIVED
DEC 20 2010
Office of the Governor

The Honorable Chris Gregoire
Governor, State of Washington
P.O. Box 40002
Olympia. Washington 98504-0002

Dear Governor Gregoire:

During last month's Governor's Aerospace Summit, our four aerospace organizations met with Randy Julin in his role as a member of the Washington State Aerospace Council. Collectively, our memberships represent over 500 aerospace suppliers, manufacturers, and professional service providers. Mr. Julin sought our input regarding the state of the industry and legislative priorities. We were grateful for his outreach and would encourage the Council to seek more industry participation in the future. As a first step, we recommend that two additional industry representatives be assigned to the Aerospace Council.

We are very optimistic about the growth and expansion of the aerospace industry in the State of Washington, particularly Boeing's continued production of the 737, 777, 747-800, and 787 and the potential air tanker and unmanned aerial vehicle's current military prowess and civilian expansion. Third-party maintenance such as parts remanufacturing and aircraft maintenance, repair and overhaul activities have a strong foundation and are focused segments, particularly for the training centers. Aerospace is very much a global industry and our memberships are poised to take advantage of the future opportunities presented by China, Canada, and our European clients. However, in an effort to retain and expand the industry's prominence, we urge you to join us in support of the following during the 2011 Legislative session:

- Workers Compensation and Unemployment Insurance Reform are significant competitive issues for aerospace as well as the other industry segments in the State of Washington. In order to reap the rewards of additional work, we have to play on a level playing field in comparison to other States.
- Continued support with of the Washington and Spokane Aerospace Technology Centers. Like many segments our core workforce is comprised of Vietnam era workers who are rapidly reaching retirement age. We are blessed with an effective community college system and four ear institutions. We believe the technology centers are responsive and progressive facilities to meet industry's demand for skilled labor.
- Protect existing aerospace tax rates.
- Oppose increased excise taxes on airplanes.
- More collaborative Aerospace-specific research and development between the University of Washington and Washington State University. At its very heart, Washington is an entrepreneurial State. The advancements of composite materials, aerospace software, aviation biofuels, and UAV's demonstrate to the world Washington's ability to literally change the
- Due to the high cost of Aerospace research, establish a mechanism to allow Washington State companies to purchase this research at reduced rates or to allow tax rebates/credits for the amount of research purchased.

- Continued emphasis and funding invested in marketing Washington Aerospace companies to foreign countries and other states outside of Washington.
- Establish a top level department under the Department of Commerce to monitor and coordinate various statewide aerospace initiatives to include:
    - Aerospace education and training
    - Aerospace research and development
    - Aerospace labor and skills availability and pipeline
    - Aerospace labor relations
    - Aerospace infrastructure requirements and availability
    - Aerospace competitive issues and economic policies

Please be assured, we understand your commitment to the continued growth and expansion of the aerospace industry.

Sincerely,

Todd Woodard
AFA

Michael Mooney
INWAC

Kevin Steck
PNAA

Brice Barrett
PNDC

APPENDIX K
STRATEGIC PLAN

Department of Aeronautics & Astronautics
University of Washington
February 2009

A. Introduction

The field of aeronautics and astronautics is concerned with the design, analysis, construction, and integration of flight vehicles and systems for atmospheric and space flight. Although the field is primarily focused on aerospace systems, it also addresses a wide range of other transportation systems, such as hydrofoils, submarines, hovercraft, and high-speed trains.[*] A broad spectrum of engineering sciences underlies the field, including aerodynamics, structural mechanics, propulsion, controls, flight mechanics, space dynamics, and plasma physics. This highlights both the multidisciplinary nature of contemporary research in Aeronautics and Astronautics, as well as the numerous opportunities for significant cross-cutting collaboration with other disciplines.

Founded in 1929, the Department of Aeronautics and Astronautics is unique at the University of Washington and in the Pacific Northwest in terms of its specific technological applications, capacity for multi-disciplinary integration of complex advanced-technology systems, and its long-term interaction with and funding by prominent local industry. The department is moderate in size, with a total of 18 tenure-track and research faculty.

B. Current Trends in Aerospace Engineering

Major recent trends that will continue over the next five years will affect the scientific, technological, and economic aspects of aerospace engineering. Among the most notable are:

- The changes of the aerospace industry from technology-driven to more economics-driven;
- The changing priorities and attitudes of government agencies and industry regarding research and development and their focus on near-term issues;
- Evolving directions in NASA's mission;
- The growing importance of new space technology for commercial, scientific and military applications;
- The rise of global terrorism, with the concomitant changes in the defense mission, both in terms of spending and direction;
- The emergence of autonomous and semi-autonomous vehicle systems for military and civilian applications;
- The transition to predominantly composite materials in aircraft

[*] Notable examples of non-aerospace studies in the Department include underwater robotics, plasma science for fusion, chemical processing, and energy systems.

- The emergence of alternative, renewable fuels for aviation
- The increasing integration of flight vehicle systems, i.e., systems of systems, in which avionics has joined the four traditional pillars: structures, aerodynamics, propulsion, and control.
- The ever-increasing interaction between air, space, ground, and sea vehicle systems and the growing emphasis on human interaction with automation;
- The emergence of new educational technologies and new priorities in public funding for higher education.

C. Addressing a Challenging Future

The Department of Aeronautics and Astronautics faces significant challenges in a future marked by shrinking funding, shifting priorities and a challenging economy. At the same time we see real opportunity to expand the research program, enhance our educational programs and reinforce the department's national and international reputation. We have identified five key goals for the next five years which are addressed in the strategic plan that follows. These goals are:

Goal 1: To establish a recognized high level of research productivity, funding and quality

Goal 2: To significantly increase national and international recognition

Goal 3: To create leading edge undergraduate and graduate education programs.

Goal 4: To achieve a leading partnership role with aerospace and other industry.

Goal 5: To significantly increase endowment funding

Goals/Metrics/Methods/Actions

Goal 1: To establish a recognized high level of research productivity, funding and quality

Metrics/Outcomes

1. All faculty active in bringing in significant research funds, support 2-3 graduate students per faculty member with department median expenditures of at least $250,000 per faculty member per year.
2. All faculty to publish at least two archival publications per year with at least one in a top-ranked journal in their respective fields.
3. All faculty active in submitting at least two proposals per year for funding from Government agencies and/or Industry.
4. A graduate research program characterized by intense participation and project ownership by the students, leading to at least two journal-quality articles for all Ph.D. efforts, and one conference paper or journal article for each MS degree.

Methods

- Chair to verify publications and proposal submission as outlined above and use in merit review.
- Develop a ranked list, based on impact factor, of journals within the four core areas in the department, and keep an up-to-date copy with the Chair. (metric 2)
- Establish sufficient fully equipped space to support research programs. (metrics 1,2,3)
- Establish support staff sufficient to meet program needs. (metrics 1,3)
- Establish research center(s) that attract faculty from outside Department to collaborate. (metrics 1,2,3)
- Establish expectation that all graduate students conducting research will present their research results both within the Department and externally.
- Note: The methods identified under Goals 2 and 3 (with respect to graduate education) provide important support to this goal. (metrics 1,2,3)

12 – 24 Month Action Priorities
Boldface indicates first year priorities

1. **Compile ranked list of archival journals**
2. Assess research space needs
    - Reactivate department space committee
    - Create budget request
3. Assess staff needs
4. **Incorporate metrics into merit review process**
5. **All faculty to submit at least two research proposals each year**
6. **Encourage sabbaticals at government agencies**
7. Adjust teaching and administrative assignments to reflect research commitments
8. Each group to identify research center opportunities
9. Identify appropriate individuals to pursue research centers
10. Create viable visiting faculty program with industry and agencies active in research.
11. **Strengthen new graduate student orientation to clearly define, in writing, Departmental expectations for graduate students.**
12. **Initiate a yearly, Departmental graduate research event for all students conducting research to present their recent results.**

Goal 2: To significantly increase national and international recognition

Metrics/Outcomes

1. Ranking: Increase undergraduate and graduate U.S. News & World Report rankings to 12 or better (Current: Graduate – 19, Undergraduate – 19).[1]
2. Department has PIs in two MURIs/IGERTs
3. Department faculty has invitations as co-PIs in five proposals for MURIs/IGERTs.
4. Add one more NSF/DoE/DoD/DoT center to the department.
5. Successfully recruit at least two world-class faculty.
6. Significantly increase the diversity of the faculty.

Methods

- Increase annual number of proposals for MURI/IGERTs and center grants (metrics 1c, 1d, 2, 3, 4, 5)
- Increase faculty cross-university collaborative efforts. (metrics 1a, 2, 3, 4, 5)
- Establish ongoing working relationships with NSF, DOD and other government research agency program management. (metrics 1a, 2, 5)
- Produce top quality (as per goal 3) undergraduates and graduates. (Metric 1a, 1b)
- Increase level of funding from government agencies and industry. (Metrics 1c,1d,2,3,5)
- Actively search to hire world-class faculty. (Metrics 1e, 4)
- Increase production of MS and PhD graduates. (Metrics 1f, 1h, 1i)
- Actively identify opportunities for faculty to receive national/international awards and recognitions, and encourage them to pursue these opportunities.
- Actively identify and pursue outstanding minority and women faculty candidates.
- Increase enrollment of graduate students with higher mean GRE scores. (Metric 1g)
- Add at least two state-funded positions (total of 17). (metrics 1c,1d,1f,1i,4)

12 – 24 Month Action Priorities
Boldface indicates first year priorities

Graduate Program

1. **Increase selectivity of graduate admissions process**
2. **Become more active in graduate recruiting**
3. **Create multi-year offers to graduate students**

[1] Assessment in order of weighed value: (a) Peer Assessment (0.25); (b) Recruiter Assessment (0.15); (c) Total Research Expenditures (0.15); (d) Average research $$ per faculty (0.10); (e) % NAE faculty (0.075); (f) Ph.D./faculty ratio (0.075); (g) Mean GRE Quantitative Scores (0.0675); (h) Doctoral degrees awarded (0.0625); (i) M.S./faculty ratio (0.0375); (j) Acceptance Rate (0.0325).

4. **Organize a single recruiting day for prospective graduate students**
5. **Have all faculty submit additional proposals for funding to increase number of graduate students**

Research

1. **Each discipline group actively cultivate new research and funding opportunities**
2. **Establish "Red Team" process for proposals - review & comment, not approval**
3. **Have quarterly discussions of research opportunities in faculty meetings**
4. Have 100% of faculty visit NSF/DoD/DoE/NASA in time frame of two years

External Relationships

1. **Perform professional update of department website**
2. **Collect and evaluate peer university information**
3. **Invite outstanding potential faculty for seminars**

Collaborative Programs

1. **Engage all faculty in this effort.**
2. ID individuals interested in MURI/IGERTs and provide appropriate support
3. ID opportunities for MURI/IGERT
4. Create handbook for creating MURI/IGERT proposals
5. Collaborative efforts: have each faculty identify one cross-university effort.

Goal 3: To create leading edge undergraduate and graduate education programs.
Boldface indicates first year priorities

Metrics/Outcomes

1. Within three months of graduation, at least 90% of students attain technical positions in industry, government, or academia.
2. At five years, at least 20% of alumni are in developing leadership positions in industry, government, or academia.
3. At least 30% of the top 10% of admitted graduate students accept admission.
4. At least 30% of the top 10% of freshmen with aero/astro preference admitted to university accept admission to department.
5. Increase URM population by at least 50% in both undergraduate and graduate populations.

Methods

- Require all undergraduates to spend two quarters either in independent research or in an internship/co-op position. (metrics 1,2)

- Graduate an average of at least three PhDs per faculty over five years. (metrics 2,3)
- Increase industry and academia/research recruitment presence with department. (metrics 1,2,3,4)
- Update undergraduate lab equipment. (metrics 1,3,4)
- Institute Direct Freshman Admission, and engage freshmen and sophomores actively in program. (metrics 1,3,4)
- Send department advertisement to all HBCUs and URM institutions. (metrics 1,2,3,4)
- Improve undergraduate and graduate awareness, and achievement, of scholarships and fellowships. (metrics 1,2,3,4)
- Increase funded graduate positions (see Goals 1 and 5). (metric 3)
- Increase outreach to local K-12 schools. (metrics 3,4)
- Maintain a continual process of assessment and improvement in both the undergraduate and graduate curricula. (metrics 1,2)

12 – 24 Month Action Priorities
Boldface indicates first year priorities

1. **Complete curriculum review by 6/15/09**
2. **Have all undergraduates spend two quarters in independent research or internship/co-op**
    a. **Update undergraduate curriculum**
    b. **Identify current percentages**
    c. **Create list of openings**
    d. **Create requirement for incoming juniors**
    a. **Actively encourage students in advising process**
3. **Admit high quality graduate students - ID candidates & invite**
4. **Implement direct freshman admission (DFA) program by Fall 2010**
    a. **Identify advising needs above what is currently offered to handle DFA**
    b. **Start DFA process for Autumn 2010 admission**
    c. **Identify activities for Freshman/Sophomore students**
        i. **AIAA - invite self-identified students to activities**
        ii. **DBF and rocket option**
        iii. **Include freshmen and sophomores in Undergraduate Seminar series**
        iv. **Identify courses that could be taken before junior year**
5. **Upgrade department website and outreach publications**
6. **Prepare recruiting brochure/flyer and broaden distribution to other schools**
7. **Improve awareness of fellowships in department website**
8. **Increase funding for PhDs students**

e. Identify current statistics
f. Identify how much funding each faculty has
g. Apply for enough funding within 12 months to cover 1-2 more students per faculty

9. Increase recruitment efforts

h. Identify who already comes
i. Identify who we want to have come
j. Invite prospective students
a. Increase URM recruitment activities

10. Assess undergraduate lab equipment needs

11. Scholarships and fellowships opportunities identified on website

a. Have list of awardees willing to share best practices

12. Create list of local K-12 schools

k. Identify science fairs
a. Set up regular lab tours

Goal 4: To achieve a leading partnership role with aerospace and other industry.

Metrics/Outcomes

1. Preferred University Status with Boeing, Aerojet and at least two other national/international companies.
2. At least two long term joint research agreements involving funding or other substantial exchange of value.

Methods (all apply to both metrics)

- Establish executive level relationships and contacts with Boeing, Aerojet and other appropriate companies.
- Establish industry-funded affiliates program.
- Increase number of active industry affiliate professors.
- Actively identify and pursue joint UW/industry funding opportunities.
- Encourage industry site visits, technical interchanges, and industry visits to the AA Department for seminars.
- Encourage faculty sabbaticals in industry/government.
- Invite industry people to serve on A&A thesis committees.
- Increase the number of student internships and co-ops.
- Actively identify and pursue funding opportunities to support joint UW/industry programs

12 – 24 Month Action Priorities
Boldface indicates first year priorities

1. **ID/inventory who has executive level contacts at companies**
   - **Where do they stand in the hierarchy**
2. **ID people in Boeing/Aerojet who could enable goal**
   - **Discipline groups ID contacts at midlevel, high level, front line**
3. **Create Boeing strategy**
4. **Create Aerojet strategy**
5. **ID students interested in internships/co-ops**
6. **Encourage sabbaticals in industry**
7. **Invite industry participation on thesis committees**
8. Increase industry affiliate faculty
9. **Encourage industrial site visits by faculty**
10. Decide on parameters of affiliates program
11. Identify likely joint funding opportunities
    a. SBIR/STTR

Goal 5: To significantly increase endowment funding

Metrics/Outcomes

1. One new permanent endowed chair/professorship.
2. Two endowed full-ride fellowships.
3. Endowment for significant improvements to infrastructure ($1M or higher endowment).

Methods (all apply to all three metrics)

- Establish departmental Development Committee to work with CoE Office of Advancement.
  a. Identify potential donors.
  b. Cultivate donor interest in Departmental programs and in donation opportunities.
  c. Assist in making important requests for donations
  d. Pursue other fund development tactics and programs.
- Actively nurture alumni and encourage gifts to department.
  a. Host regular alumni/friends social events, on and off campus - present updates on department's research, educational, and other activities at these events.

b. Build up an alumni network, i.e., encourage alumni to get together every 2-5 years, either in Seattle or elsewhere, with members of their graduating classes, and send department chair and/or 1-2 faculty to these events.
c. Increase frequency of publication of our newsletter "Highflight" to two per year.

12 – 24 Month Action Priorities
Boldface indicates first year priorities

Establish Development Committee

Appendix: Discipline-Specific Activities

1. Fluid Mechanics and Aerodynamics

In support of the Department's Strategic Plan, the members of the Fluids Group will first continue and strengthen existing research activities in advanced fluid imaging diagnostics, combustion, turbulent mixing and vortical flows, supersonic and hypersonic flow, acoustics, flows with phase change, and energy conversion. This will involve actively seeking new funding opportunities as well as the integration of a new, substantial Computational Fluid Dynamics (CFD) effort into the Group. Beyond this, the Group will aggressively explore new and emerging research areas. Aerodynamics areas of interest may include new aerodynamic designs and flow control approaches, wingtip vortex prediction and control, supersonic and hypersonic aerodynamics, and small, unmanned aero vehicles (UAVs).

Aeropropulsion research may concentrate on improved, quiet propulsion systems, ultra-low emissions combustors for subsonic and supersonic aircraft, and hypersonic propulsion. Space exploration challenges relevant to fluid mechanics may include combined rocket/airbreathing engine cycles, high-speed planetary entry vehicle aerodynamics, propulsion planetary atmosphere flight, small-scale spacecraft thrusters, and planetary *in-situ* resource utilization. In addition to these aerospace-related topics, the Group will also initiate research programs in other areas, such as microscale fluid devices for heat transfer, biomedical applications, and flow control, the fluids dynamics of underwater vehicles, geophysical fluid dynamics, and biofuels combustion.

In pursuing these new research areas the Fluids Group will actively seek to establish or continue collaborative relationships with other UW departments (e.g. ME, APL, ChemE, EE), other universities (Stanford, Kyushu University, WSU …), national laboratories (NASA Glenn Research Center, Air Force Research Laboratory), and industry (Boeing, Aerojet). The Group will also actively develop and plan for new, critically needed research and educational facilities, including additional facilities, new supersonic flow tunnels to replace capability lost in Guggenheim hall renovation, and new state-of-the-art, laser-based diagnostic techniques. Finally, the member of the Fluids Group will help elevate the profile of the Department by increasing the presence and participation of Group members at leading national and international conferences.

2. Aerospace Controls Science and Technology

Aerospace Control Science and Technology (ACST) addresses synthesis and analysis of complex interconnected dynamic systems. Our expertise encompasses efficiency, robustness, safety, and integrity of these interconnected systems. ACST graduates serve society as integrators of complex systems that keep our society connected, productive, efficient, innovative, and safe. For example, In June of 2006, in its advice to Congress, the National Research Council indicated that more than 40% of the Highest Priority Research and Technology Challenges for NASA Aeronautics are in the area of control systems technology. Miniaturization and multi-scale design, distributed and networked sensing and control, and autonomy comprise the core components of our strategic plan. Advances in these areas will shift engineering focus from vehicle optimization to optimization of the integrated vehicle/payload and networked vehicle systems.

Over the next decade, ACST will require advances in network-enabled command, control, communications, and computing technology. The group is especially strong in control theoretical and applied research that contribute to the understanding of: networked dynamic systems; real-time algorithms for autonomous path planning and mission management; innovative concepts for networked systems with limited sensing and communication; nonlinear geometric control of under-actuated systems; bioinspired sensing, actuation, and control; numerical tools for nonlinear flight dynamics; optimization tools for the synthesis of flight control augmentation systems and the integration of human operators in complex aerospace systems.

To position our department as a top research group in ACST education and research, we will: (1) Foster a spirit of academic excellence within the UW controls community, (2) Focus on the core developments in theoretical and applied aspects of ACST, (3) Maintain an enriching environment that enhances student experience and creativity, (4) Cultivate and sustain a working relationship with local industry, (5) Encourage partnerships and collaboration outside of traditionally related disciplines, and (6) Promote a reward process that encourages collaboration. Our implementation plan for the above strategic themes are: (1) Shape our research and its facilities to meet ACST and departmental goals, (2) Maintain our research and computing facilities as state-of-the-art, (3) Hire a technician capable of supporting and instructing laboratory experiments, (4) Mentor Post-Doctoral and Graduate Assistants in teaching coursework and experiments, and (5) Continue in our efforts to hire two more faculty of exceptional talent and expertise in ACST.

3. Aerospace, Structures, Materials and Mechanics

Future research in the area of aerospace materials, structures and mechanics shall focus on developing experimental and numerical tools to characterize the damage resistance and tolerance for composite-intensive airframes, including high-velocity or high-energy impact events such as bird strike, hail strike, lightning strike and crashworthiness. This will include the development of physics-based predictive tools for composite material failure, targeting both traditional autoclave prepreg materials as well as new composite material forms manufactured by low-cost techniques.

The Federal Aviation Administration-sponsored Joint Advanced Materials and Structures Center of Excellence, led by the University of Washington, is a consortium of academic institutions, aerospace companies, and government agencies seeking solutions to problems associated with existing, near- and long-term applications of composites and advanced materials for large transport commercial aircraft. The interdisciplinary nature of the center shall be further exploited to facilitate the exchange of technical and academic content between partner institutions and industry, in particular with Boeing.

In order to maintain strong research collaborations with Boeing in the area of composite materials and structures, it is necessary that the UW rise to the occasion and becomes a world-class center in the field. This can only be achieved by focusing efforts in personnel and equipment into this effort, and by making aerospace composite materials and structures a thrust area of the College of Engineering.

4. Plasma Science and Engineering

The Plasma Group has established an international reputation for leadership in innovative confinement concepts (ICCs) and computational modeling of plasmas, and expects to continue and to significantly expand both experimental and computational efforts. The Plasma Group has also made contributions to plasma propulsion and plasma-assisted manufacturing, and is well positioned to expand on these research projects.

The Plasma Group is well positioned to move forward with a large-scale compact toroid (CT) facility. Existing ICC projects have been successful and garnered much respect from the international community. Plasma faculty have the expertise and credibility to develop a large facility. Recent reorganization of DOE OFES identifies CT research as a focus area. A large-scale research effort requires additional state-supported faculty positions to provide continuity and leadership. The ideal scenario is to mentor and involve the recently hired plasma faculty and hire another in approximately 3 years. Devoting state-supported positions expresses a commitment to making plasma research a focus area, which attracts funding agencies and the best students and researchers. A large research facility requires laboratory space close to the UW campus.

On-campus projects focus on targeted research in support of larger experiments, general plasma science, plasma propulsion, and computational plasma dynamics. Campus lab space, office space, and engineering support are critical to continue these efforts. The Plasma Group, including the recent faculty hire, will further develop research projects in plasma propulsion. Computational projects (such as the PSI Center and the algorithm development efforts) provide essential support and complement the experimental projects. The computational algorithms and tools that are developed are applied to space plasmas, electric propulsion, and astrophysics. The computational projects have broad applicability, beyond fusion plasmas, with connections to the fluids group through CFD. Opportunities exist to expand these computational projects into larger, multi-institutional projects.

The Plasma Group collaborates on education and research projects, internally and with other departments and institutions. Opportunities exist to continue and expand these efforts. Our

successful graduate program should be expanded into the undergraduate curriculum. The courses would include a plasma lab and a capstone design course on plasma technologies