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May 6, 2015

MEMORANDUM

TO: State Board of Regents

FROM: David L. Buhler

SUBJECT: Utah State University – Doctor of Philosophy in Aerospace Engineering

Issue

Utah State University (USU) requests approval to offer a Doctor of Philosophy (PhD) in Aerospace Engineering effective Fall Semester, 2015. The program was approved by the USU Board of Trustees January 9, 2015.

Background

Aerospace Engineering involves the design, construction, testing, and technology development for all types of flying vehicles including airplanes, rockets, missiles, and spacecraft. Currently, the PhD in Mechanical Engineering degree is used to accommodate both mechanical and aerospace engineering doctoral students. Utah State University offers a master's degree in Aerospace Engineering. The institution believes there is sufficient student interest and industry demand to justify a new PhD program.

The proposed program requires 72 credit hours beyond the bachelor's degree and 42 credit hours beyond the master's degree. It will comply with all USU Graduate School requirements for PhD programs of study including a formal dissertation.

Within the intermountain region, only Arizona State University, University of Arizona, and the University of Colorado at Boulder offer PhD programs in Aerospace Engineering. There are no Aerospace Engineering PhD degree programs in Wyoming, Nevada, or Idaho, or within the Utah System of Higher Education (USHE). It is believed that offering the Aerospace Engineering PhD program will better position USU to capture regional talent that might otherwise leave the state. Further, this program will likely attract students to Utah who would not have previously considered USU.

According to the United States Bureau of Labor Statistics Occupational Outlook, there are some 83,000 jobs in aerospace engineering. The number of aerospace engineering jobs are expected to increase at a 7% growth rate. These positions have a median annual wage of nearly $104,000 (www.bls.gov/ooh/architecture-and-engineering/aerospace-engineers.htm).

The Utah Department of Workforce Services reports a 2.9% anticipated annual increase for aerospace engineers within Utah with 30 annual openings and median earnings of nearly $76,000 per year (http://jobs.utah.gov/wi/pubs/outlooks/state). It is expected that people prepared at the PhD level will have earnings above the median.

Overall, Utah is among the top states in the nation in the concentration of aerospace employment. Hill Air Force Base, Alliant Technology Systems, Moog, Parker-Hannifin Corporation, Boeing, and Northrop Grumman Space and Missile Systems Group, are just a few examples of key aerospace employers in Utah. Aerospace is one of the leading industry clusters targeted by the Governor's Office of Economic Development.

Despite a changing environment within the aerospace industry, where NASA's operations have scaled back significantly, demand for aerospace engineers by private, commercial, and national defense employers remains strong. Growth is primarily driven by two emerging markets: 1) unmanned aerial vehicles and their integration into civil airspace; and 2) commercial space ventures both crewed and robotic. These emerging markets will require the creation and development of highly specialized technologies and are expected to support a pool of employees prepared at the PhD level.

In addition to the need for aerospace engineers in industry and government, USU has identified 64 academic aerospace engineering programs within the United States. Students completing the PhD program at USU would be qualified candidates for positions within many of these programs. Additionally, a PhD degree in aerospace engineering would qualify graduates for select positions within mechanical engineering departments.

Policy Issues

The proposed program has been developed through established institutional procedures and Board of Regents policy. Chief Academic Officers as well as faculty in related departments from the Utah System of Higher Education institutions have reviewed the proposal and have provided input. There are no additional policy issues that need to be addressed relative to approval of the program.

Commissioner's Recommendation

The Commissioner recommends the Board of Regents approve Utah State University's request to offer the Doctor of Philosophy in Aerospace Engineering.

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David L. Buhler
Commissioner of Higher Education

DLB/BKC
Attachment

R401 Proposal
Doctor of Philosophy Degree in Aerospace Engineering
Department of Mechanical and Aerospace Engineering
Utah State University

Section I: The Request

Utah State University (USU) requests approval to offer the Doctor of Philosophy in Aerospace Engineering effective Fall Semester, 2015. The program was approved by the institutional Board of Trustees on January 9, 2015.

Section II: Program Description

Overview

The Department of Mechanical and Aerospace Engineering (MAE) at USU seeks to offer a new Doctor of Philosophy (PhD) degree program in Aerospace Engineering to complement the current Master of Science (MS) in Aerospace Engineering and the current MS and PhD programs in Mechanical Engineering. Aerospace Engineering is the primary branch of engineering associated with design, construction, testing, and technology development for all types of flying vehicles including airplanes, rockets, missiles, and spacecraft. Currently, the PhD in Mechanical Engineering degree is being used to accommodate both mechanical and aerospace engineering graduate students who successfully complete the Mechanical Engineering doctoral program. The proposed new degree program will establish a separate degree path for aerospace engineering graduate students and attract new students that specifically desire a PhD graduate degree in Aerospace Engineering. The MAE department offers sufficient foundation and aerospace courses that provide the breadth and depth needed for a quality aerospace PhD degree program without the need to develop any new courses or hire additional faculty.

PhD Degree Requirements

The PhD degree requires 72 credit hours beyond the bachelor's degree and 42 credit hours beyond the master's degree and will comply with all USU Graduate School requirements for PhD programs of study including a formal dissertation. All students must pass three PhD qualifier exams, a dissertation proposal defense, and a final dissertation defense. Requirements also consists of core courses in aerospace engineering, advanced mathematics, technical electives, and quality aerospace research. A summary of PhD degree requirements is provided below.

Aerospace Engineering (PhD) Degree Requirements	
Beyond the BS - 72 credits	Beyond the MS - 42 credits
Coursework*: 24 credits (minimum) Aerospace Core • must include MAE 5500 and 5560 if not previously completed 21 credits (minimum) Aerospace Electives/Other • No more than 6 credits MAE 7930 Doctoral Publications • No more than 6 credits MAE 5930/6930/7930 Independent Study courses. 6 credits advanced math Dissertation Research 21 credits MAE 7970 Dissertation Proposal & Final Defense *No more than 21 credits of 5000- level coursework	Coursework*: 12 credits (minimum) Aerospace Core • must include MAE 5500 and 5560 if not previously completed 6 credits (minimum) Aerospace Electives/Other • No more than 6 credits MAE 7930 Doctoral Publications • No more than 6 credit MAE 5930/6930/7930 Independent Study courses. 3 credits advanced math Dissertation Research 21 credits MAE 7970 Dissertation Proposal & Final Defense *No more than 15 credits of 5000- level coursework

Purpose of the Degree

The new degree program will attract new PhD students to the MAE graduate studies and research program and provide graduate students with the opportunity to receive a degree more directly aligned with the academic and research skills that are critical to the aerospace industry. Students completing this degree program will possess skills sought by research organizations in industry, government, and academia requiring advanced design, research, and technical management in aerospace engineering. The PhD in Aerospace Engineering will support the Utah-based aerospace industry, as well as other prominent regional and national aerospace companies and research laboratories.

Institutional Readiness

The new degree program will be administered by the MAE Department, which has in place the administrative infrastructure necessary to manage the program. Presently, the MAE department supports a PhD program in Mechanical Engineering. The PhD program in Aerospace Engineering will place more emphasis on core aerospace engineering coursework, but will not require additional institutional resources or the development of new courses. The level of effort and cost to administer this degree program will be the same as that already being provided for the Mechanical Engineering PhD degree.

Faculty

Eight faculty members in MAE have appropriate backgrounds and research interests in aerospace engineering. In the past, these faculty members have supported the MS program in Aerospace Engineering and a degree specialization in aerospace under the MS program in mechanical engineering.

Staff

Additional staff lines will not be required. The current resources within the MAE department will be able to accommodate this new program.

Library and Information Resources

Two major library resources needed for the new program are the IEEE Xplore database and a series of journals produced by the American Institute of Aeronautics and Astronautics. The Merrill-Cazier library presently subscribes to these resources.

Admission Requirements

Applicants with a bachelor's or master's degree in Aerospace Engineering or Mechanical Engineering from an ABET-accredited program can apply. For unrestricted admission to the program, students are required to have a minimum 3.3 GPA and successfully pass the GRE exam. Additional coursework in aerospace engineering fundamentals may be required in individual cases. All graduate students are expected to have a working knowledge of a computer programming language.

Student Advisement

The mechanics of admission to the program and fulfilling program requirements are handled by a full-time staff graduate advisor. As students are admitted to the program, they are assigned a temporary faculty advisor who guides them on which courses to take the first semester and how to prepare for the PhD qualification exams. During the first semester, students select a graduate committee and a major professor who advise them throughout the rest of their program.

Justification for the Number of Credits

The number of credits required for this program is the same as the currently offered PhD in Mechanical Engineering which is overseen by the Graduate School.

External Review and Accreditation

As with the current PhD program in Mechanical Engineering and practice throughout the United States, no accreditation will be sought.

Projected Enrollment

Table 1. Projected enrollment for the PhD Aerospace Engineering Degree.

Year	Student FTE	Student Headcount	# of Faculty	FTE-to-Faculty Ratio
1	0	0	8	0.0
4	2	2	8	0.25
3	4	4	8	0.50
4	6	6	8	0.75
5	8	8	8	1.00

Section III: Need

Program Need

Within the intermountain region, only Arizona State University, University of Arizona, and the University of Colorado at Boulder offer PhD programs in Aerospace Engineering. There are no Aerospace Engineering PhD degree programs in Wyoming, Nevada or Idaho, or within the Utah System of Higher Education (USHE). Thus, offering the Aerospace PhD degree better positions USU to capture regional talent that would otherwise leave the state. It is anticipated the program will attract students who would not have previously considered USU.

Labor Market Demand

According to the U.S. Department of Labor, Bureau of Labor Statistics, aerospace engineers are expected to have a 7% growth in employment during the decade of 2012 to 2022.

Overall, Utah is one of the top ten states in the nation in the concentration of aerospace employment. In 2011, the Economic Development Corporation of Utah listed the leading aerospace organizations in Northern Utah. Largest among these organizations is Hill Air Force Base (HAFB). HAFB is the host unit for the United States Air Force Material Command's 75th Air Base Wing. This unit provides support for the Ogden Air Logistics Complex (OALC) and its subordinate organizations. The OALC is the worldwide manager for a wide range of aircraft, engines, missiles, software, avionics, and accessories components. The largest private employer is Alliant Technology Systems (ATK) with the Space Systems Division groups located in Magna and Promontory, and it's Aerospace Structures Division in Clearfield.
These employers are supported by a significant group of medium-sized employers including Aircraft and Space Defense Groups of Moog Inc., the Parker-Hannifin Corporation, Boeing Utah Company, and the Northrop Grumman Space and Missile Systems Group, all of Layton Utah.
The Space Dynamics Laboratory, North Logan, Utah is a University Affiliated Research and Development Center and a sub-unit of the Utah State University Research Foundation. It is a medium-sized non-commercial employer of aerospace engineers. Space Dynamics Laboratory (SDL) expects to continue to hire new PhD aerospace engineers as they have done for the past 50 years, and it would be to SDL's advantage for these PhD engineers to attend school in Utah.

Multiple small private supplier and integration organizations provide to this network of large to medium scale employers. Examples of these small support vendors include Compositex, Inc. Sandy Utah, a manufacturer of rocketry cases and nozzles; Groen Brothers Aviation Global, Inc., Salt lake City Utah, a designer of high-performance rotorcraft for both civil and military applications; Borsight, Inc, Ogden Utah, an aerospace systems integrator; and Hypercomp, Inc., Brigham City Utah, a manufacturer of composite pressure vessels.

Despite the changing environment of the aerospace industry, where NASA's operations have scaled back significantly, demand for aerospace engineers by private, commercial, and national defense employers is still strong. Over the decade from 2012 to 2022, the Bureau of Labor Statistics projects a 7% growth in employment for aerospace engineers. This growth is primarily driven by two emerging markets 1) unmanned aerial vehicle and their integration into civil airspace, and 2) commercial space ventures both crewed and robotic. These emerging markets will require the creation and development of a wide swath of highly specialized technologies in order to become viable, and will clearly support a pool of employees with advanced aerospace engineering degrees.

In addition to the need for aerospace engineers in industry and government, USU has identified 64 academic aerospace engineering programs within the United States. Students completing the PhD program at USU would be qualified candidates for positions within many of these programs. Additionally, a PhD degree in aerospace engineering would qualify graduates for select positions within mechanical engineering departments.

Student Demand

Presently the MAE department supports a PhD in Mechanical Engineering. A new PhD in Aerospace Engineering will provide graduate students with an option that is more focused on the specialized topics that are central to aerospace engineering. Graduates with a PhD in aerospace engineering will be better prepared and more competitive in the aerospace industry. Students wanting a PhD degree in aerospace engineering will be able to stay in Utah rather than go out of state. As stated previously, this change will help to keep home-grown talent close to home.

When the PhD in Aerospace Engineering program is approved, there exists a potential for an initial small decrease in the number of students pursuing a PhD in Mechanical Engineering. However, because of the previously-described market demand and the desire of many students to choose a program with a PhD in Aerospace Engineering, overall enrollment is in MAE's PhD programs is projected to increase during the next five years.

Section IV: Impact and Benefits

Collaborations with and Impact on Other USHE Institutions

There is no anticipated impact on other USHE institutions.

Benefits

The PhD in Aerospace Engineering will directly impact the goals of USHE to prepare a workforce and develop advanced aerospace technologies that will directly impact Utah's economy. This proposed degree will make USU graduates more competitive for aerospace engineering positions within Utah as well as elsewhere in the aerospace industry. By having more engineers educated and trained for their needs, the Utah aerospace companies are, presumably, going to be more competitive in competing for new contracts and developing new aerospace technologies.

Consistency with Institutional Mission

The mission of USU is to be one of the nation's premier student-centered land-grant and space-grant universities by fostering the principle that academics come first, by cultivating diversity of thought and culture, and by serving the public through learning, discovery, and engagement.

The proposed PhD in Aerospace Engineering enhances the University's reputation as a space-grant institution through both its graduates and research productivity. It supports the University Mission Statement in the following ways:

1. The department becomes more student-centered by providing a program to meet the needs of the students.
2. The doctoral program will improve academics in aerospace engineering by fostering research in the forefront of the field, consistent with the USU mission to be one of the nation's premier space-grant universities.

The doctoral program will serve the public by application of the research produced. It will also serve the growing aerospace industry in Utah with a better-prepared work force.

Section V: Program and Student Assessment

Program Assessment

The major goal for the program is to graduate PhD students with expertise in aerospace engineering and who are prepared to meet the needs of research organizations in industry and academia. Attainment of this goal will be measured by the placement rate of graduates within local and national research laboratories in industry, government, and academia.

Expected Standards of Performance

The standard of performance for all students is a grade of C or better in all classes required for the degree and to maintain an overall program GPA of 3.0 or higher in order to graduate with a PhD degree. In addition, all PhD students must satisfactorily pass a set of qualification exams within 3 semesters of being admitted to the aerospace engineering PhD program, and pass a dissertation defense upon completion of their dissertation research. PhD students are also expected to publish in peer-reviewed journals before completing their PhD program of study. These standards are already well established in the Graduate School as well as for the existing Mechanical Engineering PhD degree program.

Section VI: Finance

Funding Sources

The proposed PhD in Aerospace Engineering builds on MAE's MS in Aerospace Engineering Program and the aerospace specialization in place within MAE's undergraduate program. Additional funding is not required.

Reallocation

No budget transfers or reallocations will be requested or needed to offer a quality program as explained in the next section.

Impact on Existing Budget

A new aerospace PhD degree will enhance the MAE graduate program with virtually no impact on existing budgets.

Faculty

This new degree will have no impact on faculty salaries since new faculty positions are not needed to offer the degree. In reality, each professor is constantly managing his/her time to maintain a research program that includes preparing proposals, contract management, student mentoring, teaching courses, publishing research results, and providing University and professional service. Experience has shown that even though the required student contact time increases with the number of graduate advisees, the overall workload may not increase but actually decrease because there is more graduate student support for developing and maintaining the research productivity. The MAE faculty members feel that the benefits of the projected enrollment offset the time costs to manage the program.

Staff

This new degree program will have no impact on staff work load and staff salaries.

Facilities

During the past five years, the MAE department has been planning for and working toward increased graduate enrollment and has sufficient office/study space to accommodate the expected small enrollment increase. Most of the incidental cost associated with graduate students is already covered by the research grants/contracts such that the impact on Education & General funds is expected to minimal.

Operating Costs

Increase in enrollment results in increased copy service charges and other miscellaneous expenses. The MAE department has already been using electronic communications more and more to curb paper and copy expenses. This will continue such that these costs will be minimal for this degree program. In summary, the additional work load imposed by this degree is minimal and will have no impact on tasks that would normally be done by current faculty and staff.

Budget Explanation

Salaries, wages, and benefits are estimates of the marginal costs of offering PhD level instruction based on the USHE cost study. Since these courses are already being taught, the revenue to pay for these expenses is simply a reallocation within current department funds. Thus, the difference, revenue less expenses, is zero. The teaching expenses are based on eight faculty members with an approximately 50% teaching role assignment, and with a 50/50 split between mechanical engineering courses and aerospace engineering courses. The expenses are thus approximately 25% of current salaries, wages, and benefits for these faculty members. Note that any additional expenses associated with research will be externally funded.
Additional comments for Table 2:

- FTE = 10 credits
- Tuition increase is estimated at 8%.
- Salary and Wages increase is estimated at 3%.
- Benefit increase follows the Sponsored Programs rates
- No new funding is required for this program.

Table 2. Projected Aerospace PhD Program Revenue and Expenses

		Year 1	Year 2	Year 3	Year 4	Year 5
Students						
	Projected FTE	4	6	8	9	10
	Cost Per FTE	12,173	10,843	9,811	9,455	9,139
	Student/Faculty Ratio	0.50	0.75	1.00	1.13	1.25
Projected Tuition						
	Gross Tuition	21,897	35,473	51,081	62,063	74,476
	Tuition to Program	0	0	0	0	0
5 Year Budget Projection						
		Year 1	Year 2	Year 3	Year 4	Year 5
Expenses						
	Salaries & Wages	93,727	96,539	99,435	102,418	105,491
	Benefits	40,303	40,303	40,303	40,303	40,303
	Total Personnel	134,030	136,841	139,738	142,721	145,793
	Current Expense	38,820	38,820	38,820	38,820	38,820
	Travel					
	Capital					
	Library Expense					
Total Expense		172,850	175,662	178,558	181,541	184,614
Revenue						
	Legislative Appropriation					
	Grants					
	Reallocation	172,850	175,662	178,558	181,541	184,614
	Tuition to Program					
	Fees					
Total Revenue		172,850	175,662	178,558	181,541	184,614
Difference	Revenue-Expense	0	0	0	0	0

Appendix A: Program Curriculum

All Program Courses

PhD Beyond BS	
Course Requirements	Credit Hours (minimum)
Core Courses	24
Math Courses	6
Dissertation Research	21

Technical electives/other credits	21
Total Credits	72

PhD Beyond MS	
Course Requirements	Credit Hours (minimum)
Core Courses	12
Math Course	3
Dissertation Research	21
Technical electives/other credits	6
Total Credits	42

Existing Aerospace Core Courses

Fall Semester
- MAE 5500 Aerodynamics
- MAE 5560 Dynamics of Space Flight
- MAE 6500 Potential Flow
- MAE 6510 Aircraft Dynamics and Flight Simulation
- MAE 6540 Advanced Astrodynamics
- MAE 7540 Advanced Astrodynamics Techniques/Applications

Spring Semester
- MAE 6340 Spacecraft Attitude Control
- MAE 6560 Spacecraft Navigation
- MAE 6930 Advanced Control of Aero Vehicles

Summer Semester
- MAE 6530 Advanced Propulsion
- MAE 6570 Optimal Space Guidance
- MAE 6930 Monte Carlo and Linear Covariance Techniques
- MAE 7560 Optimal Estimation/Aerospace

Aerospace Technical Electives

Fall Semester
- MAE 5310 Dynamic Systems and Controls
- MAE 5420 Compressible Fluid Flow
- MAE 6180 Dynamics & Vibrations
- MAE 6410 Fluid Dynamics
- MAE 7360 Optimal and Robust Control
- MAE 6320 Linear Multivariable Control
- ECE 5230 Space Systems Engineering
- ECE 6240 Space Environment Engineering
- ECE 6650 Optics I

Spring Semester
- MAE 5440 Computational Fluid Dynamics
- MAE 5510 Dynamics of Atmospheric Flight

MAE 5540 Propulsion Systems
MAE 6440 Advanced Computational Fluid Dynamics
MAE 6490 Turbulence*
MAE 6550 Advanced Structural Analysis
MAE 7330 Nonlinear and Adaptive Control
MAE 7350 Intelligent Control Systems

All Semesters (Fall, Spring, and Summer)

MAE 5930, 6930, 7930 Special Topics (must be Aero focused)

Approved Mathematics Courses

MATH 5270: Complex Variables
MATH 5410: Methods of Applied Mathematics
MATH 5420: Partial Differential Equations
MATH 5460: Introduction to Theory and Application of Nonlinear Dynamics Systems
MATH 5760: Stochastic Processes
MATH 6270: Complex Variables
MATH 6410: Ordinary Differential Equations I
MATH 6420: Partial Differential Equations I
MATH 6440: Ordinary Differential Equations II
MATH 6450: Partial Differential Equations II
MATH 6470: Advanced Asymptotic Methods
MATH 6610: Numerical Analysis
MATH 6620: Numerical Analysis
MATH 6640: Optimization
ECE 6010: Stochastic Processes in Electronic Systems
ECE 6030: Mathematical Methods for Signals and Systems
STAT 5200 Design of Experiments
MAE 7560 Optimal Estimation for Aerospace Systems

New Courses to be Added in the Next Five Years

No new courses are currently planned. However, to enhance the program and continually strengthen its relevance, it is expected that new courses will be integrated over time.

Appendix B: Program Schedule

The following is a sample program of study for the Aerospace Engineering PhD beyond the baccalaureate degree.

PhD Aerospace Engineering (Year 1)			Year 1 Credits
Fall 1	Spring 1	Summer 1	
MAE 5500	MAE 6340	MAE 6530	
MAE 5560	MAE 5540[1]		
MAE 5420[1]	MAE 5440[1]		
9 hours	9 hours	3	21

[1] Technical Elective

PhD Aerospace Engineering (Year 2)			Year 2 Credits
Fall 2	Spring 2	Summer 2	
MAE 6500	MAE 6560	MAE 6570	
MAE 6540	Math 5420		
MAE 5310[1]	MAE 6440[1]		
9 hours	9 hours	3 hours	21

[1] Technical Elective

PhD Aerospace Engineering (Year 3)			Year 3 Credits
Fall 3	Spring 3	Summer 3	
MAE 6410[1]	MAE 7970	MAE 7560[m]	
ECE 5230[1]			
6 hours	9 hours	3 hours	18

[1] Technical Elective [m] Math Course

PhD Aerospace Engineering (Year 4)			Year 4 Credits
Fall 4	Spring 4	Summer 4	
MAE 7970	MAE 7970		
6 hours	6 hours		12

Total Credits	72

The following is a sample program of study for the Aerospace Engineering PhD beyond the master's degree.

PhD Aerospace Engineering (Year 1)			Year 1 Credits
Fall 1	Spring 1	Summer 1	
MAE 5500	MAE 6340	MAE 6530	
MAE 5560	MAE 5540[1]		
MAE 5420[1]	MATH 5420		
9 hours	9 hours	3	21

[1] Technical Elective

PhD Aerospace Engineering (Year 2)			Year 2 Credits
Fall 2	Spring 2	Summer 2	
MAE 7970	MAE 7970		
6 hours	6 hours		12

[1] Technical Elective

PhD Aerospace Engineering (Year 3)			Year 3 Credits
Fall 3	Spring 3	Summer 3	
MAE 7970	MAE 7970		
6 hours	3 hours		9

Total Credits	42

Appendix C: Faculty

Professors:

Christine Hailey - PhD Mechanical Engineering, University of Oklahoma, 1985 (aerodynamics and flight mechanics)

Associate Professors:

Rees Fullmer – PhD Mechanics Engineering, University of Utah, 1985 (guidance, navigation and control)
Steven Folkman - PhD Mechanical Engineering, Utah State University, 1990 (aerospace structures)
David Geller - PhD Space Physics and Astronomy, Rice University, 1999 (guidance, navigation and control)
Steven Whitmore - PhD Aerospace Engineering, University of California, Los Angeles, 1989 (propulsion)

Assistant Professors:

Aaron Katz - PhD Aeronautics and Astronautics, Stanford University, 2009 (computational fluid dynamics)
Currently two additional faculty positions are being filled at the assistant professor level to support the needs of the Aerospace Engineering curriculum.