2006-2186: SEPARATING AERO AND SPACE: ESTABLISHING A DUAL TRACK FOR AEROSPACE ENGINEERING STUDENTS

Thomas Hannigan, Mississippi State University

Thomas Hannigan is an Instructor of Aerospace Engineering and Engineering Mechanics. He received his BS and MS degrees from Mississippi State University. His interests include introductory engineering mechanics, airplane flight mechanics, and he coordinates laboratory activities for the department. He holds FAA Gold Seal Flight Instructor Certification for single, multi engine and instrument airplanes.

Carrie Olsen, Mississippi State University

Carrie Olsen is an Assistant Professor of Aerospace Engineering. She received her BS and MS degrees from Mississippi State University and her Ph.D. from the University of Texas at Austin. She has 18 years of work experience with NASA in the areas of orbital mechanics, mission planning and mission operations. Dr. Olsen teaches upper division and graduate courses in orbital mechanics, space mission design and related topics. Her research interests are in aspects of orbital mechanics as related to space mission planning and operations.

David Bridges, Mississippi State University

David Bridges is an Associate Professor of Aerospace Engineering at Mississippi State University. He received his B.S. and M.S. degrees in Aerospace Engineering from Mississippi State, and his Ph.D. in Aeronautics from the California Institute of Technology. He teaches undergraduate and graduate aerodynamics courses as well as aircraft performance and stability courses on the undergraduate level. His interests are in separated flows, vortical flows, and boundary layer stability and transition.

Keith Koenig, Mississippi State University

Keith Koenig is a Professor of Aerospace Engineering. He received his BS degree from Mississippi State University and his MS and PhD degrees from the California Institute of Technology. Prof. Koenig teaches introductory courses in aerospace engineering and flight mechanics, and upper division courses in aerodynamics and propulsion. His research areas include rocket and scramjet propulsion and sports equipment engineering.

Separating Aero and Space: Establishing a Dual Track for Aerospace Engineering Students

Introduction

The recent renewal of interest in returning to space, with manned missions to the Moon and Mars being actively discussed and planned, has caused a resurgence in student interest in aerospace engineering. The success of the X-Prize competition at spurring private manned space development has also fueled the imaginations and heightened the motivation of students to study space related topics, and to pursue a college degree that will prepare them to work in the space industry. Meanwhile, a very mature space industry already exists to support a myriad of space-related industries. Informal surveys of entering freshmen indicate that nearly half of them would like to work in space-related jobs during their aerospace engineering careers. The depth and breadth of a well established and diverse aerospace engineering program, and the emphasis of this program primarily on aeronautical education, research, and technology development is documented. The contrast of the needs of employers in support of space-related industries, from industry and alumni perspectives is described. The discussions that established a definitive need for a dual track system for aerospace engineering students are detailed. The process that led to the implementation of a revised curriculum is described. To begin the process of changing the aerospace engineering curriculum to better server the needs of undergraduates interested in a greater emphasis on space-related courses, an internet study of the published curricula of various institutions was conducted. Synopses of each program investigated are included, and contrasts and similarities noted along with a discussion of the wide variety of ways that the common requirements are implemented. Changes to courses ranging from introductory, intermediate and upper division and technical electives, and laboratory courses are described. Development of additional technical elective and graduate courses are discussed.

Background

The official program description that has been listed in Mississippi State University catalogs for many years expressed the intention to graduate students well prepared to enter into the national aerospace engineering workforce: The Department of Aerospace Engineering at Mississippi State University provides an accredited undergraduate curriculum with the mission of preparing students to enter the workplace as qualified entry-level aerospace engineers or to enter any aerospace engineering graduate program adequately prepared for advanced study. This mission is accomplished by a strong foundation in mathematics and physical and engineering sciences upon which student problem solving and application skills are developed. The curriculum stresses analytical and communication skills, with particular emphasis placed on engineering design throughout the curriculum. A capstone design experience in the senior year provides the opportunity to integrate design, analytical, and problem solving skills along with communication skills in a team environment which emulates aerospace engineering practice.

The mission[1] of this Aerospace Engineering Department is accomplished by the following learning objectives:

1. Provide a strong foundation in the fundamentals of mathematics, basic physical sciences, and engineering sciences.
2. Develop analytical and problem-solving skills and proficiency in the use of techniques and tools that implement these skills.
3. Develop design skills and integrate design throughout the curriculum.
4. Develop proficiency in written, oral, and graphic communication.
5. Introduce and develop an appreciation for the arts, humanities, and social sciences.
6. Promote engineering ethics, personal integrity and responsibility, and professionalism.
7. Develop teamwork and leadership skills.
8. Instill a commitment to lifelong learning.

The aerospace engineering program is accredited under the EC 2000 criteria by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology.

The crux of changes to this long-standing program of aerospace engineering are summarized in the following addition to this official program description inserted prior to the accreditation statement: These objectives are accomplished in two different concentrations in the aerospace engineering curriculum, an aeronautics concentration and an astronautics concentration. The concentration in aeronautics focuses on the analysis and design of aircraft and other vehicles that operate primarily within the earth's atmosphere, and the concentration in astronautics focuses on the analysis and design of spacecraft and other vehicles that operate primarily outside the earth's atmosphere. A student in aerospace engineering will choose one of these two concentrations when pre-registering for the junior year.

The impetus and justification for making this small but substantial change in the curriculum of aerospace engineering came from within and without. Students have long expressed a strong interest in space-related topics[2], and surges in employment opportunities with periodic space endeavors has had a strong impact on student recruitment and retention. Likewise, the visits to campus and strong recruitment has been quite cyclical, but over the long haul, the employment of graduates of this program by space related industries has been steady. In fact, graduates of this program have successfully risen through the ranks in many NASA facilities as well as the primary research laboratories of many companies. A number of those individuals serve on the advisory boards for this department and others, and over time it has become clear that the needs of our constituents, both students and in industry, were not being met by the current curriculum. Although the name of the program was aerospace engineering, the criteria for that designation was met in minimal fashion.

For a program to be accredited as an aerospace engineering program[3] under ABET guidelines, a program must thoroughly cover one of the subject areas of aeronautical engineering or astronautical engineering and have more than one course in the other subject area. For many years, the ASE program at Mississippi State has qualified under this minimal standard. The curriculum thoroughly covered the subject of aeronautical engineering, which deals with the analysis and design of airplanes. Students were required to take one course devoted to astrodynamics, and a significant portion (at least one-third) of the aerospace propulsion course has dealt with rocket propulsion. Because of recent additions to the ASE faculty, this department is now in a position to offer a true concentration in astronautics that includes courses in orbital mechanics, spacecraft dynamics, and spacecraft design. Thus the department is in a position to offer a space-oriented program to those students who are more interested in astronautics than aeronautics. For those students who wish to study airplanes and not spacecraft, the elimination of the previously-required course in astrodynamics will open up a second technical elective that will allow those students to pursue their interests in aircraft in more depth. Students in the astronautics concentration will also have two technical electives.

The previous one-track curriculum is listed below. Note that beyond the University Core, most ASE courses were primarily aeronautical courses, or courses with minimal space related content.

Department of Aerospace Engineering (ASE) – One Track Curriculum

University Core (36 hours / 21 hours not in major core)

English Composition (6 hours)
- EN 1103 English Comp I or
- EN 1163 Accelerated Comp I
- EN 1113 English Comp II or
- EN 1173 Accelerated Comp II

Mathematics (9 hours)
- See Major Core

Science (6 hours)
- See Major Core

Humanities (6 hours)
- See University CORE

Fine Arts (3 hours)
- See University CORE

Social/Behavioral Sciences (6 hours)
- See University CORE

Major Core

Math and Basic Science (31 hours)
- MA 1713 Calculus I
- MA 1723 Calculus II
- MA 2733 Calculus III
- MA 2743 Calculus IV
- MA 3253 Differential Equations I
- 3 hours Math/Science Elective
- CH 1213 Fundamentals of Chemistry
- CH 1211 Investigations of Chemistry
- PH 2213 Physics I
- PH 2223 Physics II
- PH 2233 Physics III

Engineering Topics (70 hours)
- ECE 3183 Electrical Engineering Systems
- EM 2413 Engineering Mechanics I
- EM 2433 Engineering Mechanics II
- EM 3213 Mechanics of Materials
- EM 3313 Fluid Mechanics
- EM 3413 Vibrations
- ASE 1013 Intro to Aerospace Engineering
- ASE 1023 Intro to Flight Mechanics
- ASE 2013 Astro, Propulsion, Structures
- ASE 3333 Aerothermodynamics
- ASE 3123 Static Stability and Control
- ASE 3213 Aircraft Structures I
- ASE 3223 Aircraft Structures II
- ASE 3313 Incompressible Aerodynamics
- ASE 4113 Aerospace Engineering Lab I
- ASE 4123 Dynamic Stability and Control
- ASE 4143 Astrodynamics I
- ASE 4343 Compressible Aerodynamics
- ASE 4721 Aerospace Engineering Lab II
- ASE 4413 Aerospace Propulsion
- ASE 4623 Aircraft Structures III
- ASE 4513 Aerospace Vehicle Design I
- ASE 4523 Aerospace Vehicle Design II
- 3 hours Technical Electives*

General Topics (6 hours)

GE 3513	Technical Writing	CO 1003	Fundamentals of Public Speaking

Total hours needed for major: 128

*The technical electives may be selected from the following: Any of the department's listing of Advanced Undergraduate/Graduate Courses, or EM 4123 or EM 4133. Other courses in computer science, physical science, mathematics, and engineering may be elected, with special approval of the department.

Modification of this curriculum followed a detailed study of the curricula at other institutions and a careful look at the needs of the current students, in close consultation with department and university curriculum committees and the advisory committee. Feedback following the curriculum modifications will be presented later. The following summarizes research into modification of the curriculum conducted by Olsen, and presented to the committees as a basis for beginning the formal modifications of curriculum and courses.

Research on Aerospace Engineering Curricula

In order to begin the process of changing the aerospace engineering curriculum to better serve the needs of undergraduates interested in a greater emphasis on space-related courses, an internet study was undertaken of the published curricula of twenty-five aerospace engineering programs across the nation. Short synopses of each program investigated are included in Appendix C. The study was restricted to four-year public institutions, although the investigator also looked briefly at Georgia Tech and Notre Dame for sake of comparison. The investigation revealed at substantial similarities between all the programs, due to the ABET-imposed standards for aerospace engineering programs. However, the study also discovered a wide variety of methods for implementing the common requirements. The freshman and sophomore year curricula were found to be highly standardized across the studied programs. Some significant differences were found in "Intro to Aero" courses or sequences and some universities emphasized the early acquisition of computer programming skills more than others.

It was somewhat surprising that very few universities offered a true "split" curriculum – a chance to declare a concentration in either aeronautics or astronautics. Furthermore, the degree of split was found to be a continuum – from offering only separate aircraft and spacecraft design experiences to fairly specialized curricula in the last three semesters. Other than the Air Force and Naval Academies, whose curricula were judged too far "out of family" to emulate, owing to the large number of military officer preparatory classes, only three curricula examined appeared to offer two separate concentrations: The University of Texas at Austin, Purdue University and The University of Maryland.

Several institutions that offer a large selection of space-related courses for their students allow for a great deal of flexibility in the senior year. Very few required courses were listed in their senior curricula. For instance, Purdue allows for six hours of technical electives and 15 hours of "Major or Minor Area Electives" in the last three semesters. An incredible list of courses is offered for the student to pick from. This flexibility is accomplished by requiring only one structures course, one aerodynamics course, combining Dynamics and Vibrations into one course, sprinkling lab courses throughout the last five semesters (four one-hour courses associated with corresponding lecture courses), and having a 131-semester hour curriculum. This 131-hour total is 3 to 7 hours more than most curricula examined.

Given what was learned studying the internet sites of the 25 programs, and factoring in the relatively small size of the Mississippi State faculty and undergraduate enrollment, the following observations and suggestions for curriculum changes and topics for further discussion were developed.

Our current single-track curriculum requires three structures courses. While some programs require only one or two, many others also have three. Are all three pertinent to both aeronautics and astronautics? Is it possible to make one of the three an elective?

Our laboratory courses are concentrated in a three-hour course in spring of the junior year and a one-hour course in fall of the senior year. Are the topics covered of interest to both astronautics and aeronautics students? Would it be advantageous to split the lab sequence into astronautics and aeronautics sections in the 2nd semester, at least? Do the topics covered need to be "updated" for pertinence to today's aerospace industry? The impetus for asking these questions comes from the wide variety of lab courses seen at the universities studied. Texas, for example, had a "Satellite Applications Lab" for its astronautics students that dealt with navigation equipment and a "Spacecraft Mission Design Lab" where students were taught to solve astrodynamics problems using common COTS software like STK.

From what was learned it seems apparent that astronautics students should be required to take only one aerodynamics class and one aircraft flight mechanics class. The aeronautics students would probably still take two of each. This is a fairly standard breakdown for schools offering curriculum customization. In consult with the chair of the curriculum committee, the topics covered in the current courses might need to be rearranged to insure that students in both concentrations are exposed to the necessary topics for their disciplines. In place of the second aerodynamics and aircraft flight mechanics classes, the astronautics students would take a broad, fairly high-level orbital mechanics class and one on spacecraft attitude dynamics. These two courses are essential and should be required. A more advanced orbital mechanics course should be offered as a senior elective/graduate course. On the other hand, the aeronautics students should no longer be required to take orbital mechanics.

Many schools offer an Aerospace Controls course that is separate from Aircraft Flight Mechanics and Spacecraft Attitude Dynamics. It is taken by both concentrations and often includes a Lab. Our program may want to consider adopting this arrangement as well.

The question was raised that a decision must be made to continue to teach one, combined propulsion course or to split propulsion into Rocket Propulsion and Jet Propulsion. This decision holds implications for the aerodynamics topics that will be deemed "required" for the astronautics students. In addition, the size of our faculty and availability of an instructor for two propulsion classes verses one must be considered.

The Capstone Design Experience: There is no doubt that the students should be given a choice here. What must be determined is whether both semester courses required in system design are to be completely separately, or if the first semester would meet jointly – aeronautics and astronautics together. This is an area where current systems design faculty would greatly benefit from interacting with faculty members from other programs. Also, on the astronautics side there is some variance in course titles and content. Some programs call the course Spacecraft Design, and others Space Systems Design. Some include Mission Design in the course and others have separate Mission Design courses that follow from the more basic orbital mechanics classes.

Discussion

The impetus to put more space into the aerospace curriculum began years earlier, in discussions at faculty meetings and annual planning retreats. As has been previously stated, the cyclical nature of the aerospace engineering industries, both aeronautical and astronautical (air and space), has resulted in a constant flux of students clamoring for particular technical courses. Fluctuations in faculty and their research programs, and the sudden growth of space-derivative technology likewise fueled the desire for a more definitive and focused curriculum. The recent resurgence of atmospheric vehicles, particularly manned and unmanned surveillance and combat vehicles emphasized that the need for aeronautical engineers was by no means diminished. It was not mere happenstance that when several new faculty were hired in recent years, that they would be faculty that were schooled in aeronautics, but employed in space industry. There was a stated intention to put space back into aerospace, and that intention was being systematically carried out through the introduction of courses beginning in the freshman year concentrating on exposing students to the depth and breadth of aerospace engineering. Though various courses had by design included some of what would be considered space topics, there was an obvious need to go further, to allow students to have a more complete educational endeavor that would prepare them adequately for a jump into the respective branches of aerospace engineering.

Thus, after formal consideration of options for curriculum change, and in the spirit of remaining a current and viable program, a concerted effort to adopt a two-track system was undertaken. The survey of peer and peer-plus institutions provided a more firm basis for the separation of the upper division, but it took a concerted effort to consider all of the impact of such separation on both existing and new courses. This effort resulted in the delineation of the two-track curriculum, and descriptions of the new and revised courses. Then the real work began with the promulgation of formal proposals for course modifications and development, and the review of those proposals by individuals from within and without the university system, including professionals from the various industries that would potentially be directly influenced.
Finally, complete proposals, modified as necessary in response to the feedback and assessment of department plans, were submitted through the university curriculum committee for approval of these plans. It is to the credit of the faculty involved that they had anticipated and provided information on virtually every concern expressed by members of the advisory committee and by university course and curriculum committee. It was the consensus of all concerned that the two-track curriculum detailed below would guide the department in the correct direction for the foreseeable future.

Department of Aerospace Engineering (ASE) – New Curriculum (Fall 2006)

University Core (36 hours / 21 hours not in major core)

English Composition (6 hours)

EN 1103	English Comp I or
EN 1163	Accelerated Comp I
EN 1113	English Comp II or
EN 1173	Accelerated Comp II

Mathematics (9 hours)
See Major Core

Science (6 hours)
See Major Core

Humanities (6 hours)
See University CORE

Fine Arts (3 hours)
See University CORE

Social/Behavioral Sciences (6 hours)
See University CORE

Major Core

Math and Basic Science (31 hours)

MA 1713	Calculus I
MA 1723	Calculus II
MA 2733	Calculus III
MA 2743	Calculus IV
MA 3253	Differential Equations I
3 hours	Math/Science Elective
CH 1213	Fundamentals of Chemistry
CH 1211	Investigations of Chemistry
PH 2213	Physics I
PH 2223	Physics II
PH 2233	Physics III

Engineering Topics (55 hours)

ECE 3183	Electrical Engineering Systems
EM 2413	Engineering Mechanics I
EM 2433	Engineering Mechanics II
EM 3213	Mechanics of Materials
EM 3313	Fluid Mechanics
EM 3413	Vibrations
ASE 1013	Intro to Aerospace Engineering
ASE 1023	Intro to Flight Mechanics
ASE 2013	Astrodynamics, Propulsion, and Structures
ASE 3333	Aerothermodynamics
ASE 3213	Mechanics of Deformable Structures
ASE 3223	Aerospace Structural Analysis
ASE 4113	Aerospace Engineering Lab I
ASE 4123	Aerospace Controls
ASE 4343	Compressible Aerodynamics
ASE 4721	Aerospace Engineering Lab II
ASE 4623	Aerospace Structural Design
6 hours	Technical Electives*

Aeronautics Concentration (15 hours)

ASE 3123	Aircraft Attitude Dynamics
ASE 3313	Incompressible Aerodynamics
ASE 4413	Aircraft Propulsion
ASE 4513	Aircraft Design I
ASE 4523	Aircraft Design II

Astronautics Concentration (15 hours)

ASE 3813	Intro to Orbital Mechanics
ASE 3823	Spacecraft Attitude Dynamics
ASE 4443	Spacecraft Propulsion
ASE 4533	Spacecraft Design I
ASE 4543	Spacecraft Design II

General Topics (6 hours)

GE 3513	Technical Writing
CO 1003	Fundamentals of Public Speaking

Total hours needed for major: 128

---

* The technical electives may be selected from the following: Any of the department's listing of Advanced Undergraduate/Graduate Courses, or EM 4123 or EM 4133. Other courses in computer science, physical science, mathematics, and engineering may be elected, with special approval of the department. Any required course in one concentration qualifies as a technical elective for a student in the other concentration.

Courses Specific to Concentrations

Aeronautics Concentration

ASE 3123 Aircraft Attitude Dynamics. (3) (Prerequisites: ASE 2013, EM 2433, credit or registration in EM 3413). Three hours lecture. Longitudinal, directional, and lateral static stability and control; related aerodynamics; maneuvering flight; introduction to dynamic stability and control analysis methods; general equation of unsteady motion.

ASE 3333 Incompressible Aerodynamics. (Prerequisite: EM 3313). Three hours lecture. Potential theory of bodies; airfoil theory and applications; finite wing theory and applications; introduction to Navier-Stokes equations; laminar boundary layers; turbulent boundary layers.

ASE 4413 Aircraft Propulsion. (3) (Prerequisites: ASE 3333 and ASE 4343). Three hours lecture. Aerothermodynamics of aircraft jet engines and gas turbine engine components; nozzles; turbines; compressors; diffusers; introduction to piston engines; propellers and propeller performance estimation.

ASE 4513 Aircraft Design I. (3) (Prerequisities: ASE 3123, ASE 3313,ASE 3223). Two hours lecture. Three hours laboratory. Introduction to the principles and techniques of aircraft design. Introduction to systems engineering and requirements analysis; design optimization; layout; weight; performance.

ASE 4523 Aircraft Design II. (3) (Prerequisite: ASE 4513). One hour lecture. Five hours laboratory. Continuation of ASE 4513. Students make use of principles and techniques covered in ASE 4513 to create a design of an aircraft.

Astronautics Concentration

ASE 3813 Introduction to Orbital Mechanics. (3) (Prerequisite: EM 2433, MA 3253). Three hours lecture. Two-body orbital mechanics; geometry of spatial orbits; fundamental orbit determination; orbital maneuvers; introduction to rendezvous and interplanetary trajectories.

ASE 3823 Spacecraft Attitude Dynamics. (3) (Prerequisite: ASE 3813). Three hours lecture. Motion of spacecraft about center of gravity. Rigid body dynamics and rotational kinematics. Mission pointing requirements and design of the attitude determination and control system.

ASE 4443 Spacecraft Propulsion. (3) (Prerequisites: ASE 3333 and ASE 4343). Three hours lecture. Nozzles and thermochemistry. Components, design and performance of liquid propellant, solid propellant, hybrid and electric rocket propulsion systems.

ASE 4533 Spacecraft Design I. (3) (Prerequisites: ASE 3223, ASE 3823). Two hours lecture. Three hours laboratory. Introduction to the principles and techniques of spacecraft and mission design. Systems engineering and requirements analysis, spacecraft system characteristics and mission phases.

ASE 4543 Spacecraft Design II. (3) (Prerequisite: ASE 4533). One hour lecture. Five hours laboratory. Continuation of ASE 4533, Spacecraft Design I. Application of design concepts and principles. Concentration on systems engineering, detail design, life cycle cost, manufacturing and operations.

Semester Outline

Freshman and Sophomore years are unchanged. In lists below, “Aero” indicates Aeronautics concentration and “Astro” indicates Astronautics concentration.

Junior Year	**Hours**
Fall	
ASE 3333 Aerothermodynamics	3
ASE 3213 Mechanics of Deformable Structures	3
ECE 3183 EE Systems	3
EM 3413 Vibrations	3
EM 3313 Fluid Mechanics (Aero) **OR** ASE 3813 Intro to Orbital Mechanics (Astro)	3
	16
Spring	
ASE 3223 Aerospace Structural Analysis	3
ASE 4113 Aerospace Engineering Lab I	3
GE 3513 Technical Writing	3
ASE 3313 Incompressible Aerodynamics (Aero) **OR** EM 3313 Fluid Mechanics (Astro)	3
ASE 3123 Aircraft Attitude Dynamics (Aero) **OR** ASE 3823 Spacecraft Attitude Dynamics (Astro)	3
	15

Senior Year	
Fall	
ASE 4123 Aerospace Controls	3
ASE 4623 Aerospace Structural Design	3
ASE 4721 Aerospace Engineering Lab II	1
ASE 4343 Compressible Aerodynamics	3
ASE 4513 Aircraft Design I (Aero) **OR** ASE 4533 Spacecraft Design I (Astro)	3
ASE Technical Elective	3
	16
Spring	
ASE Technical Elective	3
Math/Science Elective	3
Fine Arts Elective	3
ASE 4413 Aircraft Propulsion (Aero) **OR** ASE 4443 Spacecraft Propulsion (Astro)	3
ASE 4523 Aircraft Design II (Aero) **OR** ASE 4543 Spacecraft Design (Astro)	3
	15

Summary of changes made to provide concentrations in Aeronautics and Astronautics

A basic change to the ASE program that results from the introduction of the Aeronautics and Astronautics is the elimination of one required course and its replacement with a technical elective. Students in the Aeronautics concentration will no longer have to take ASE 3813 Introduction to Orbital Mechanics, and students in the Astronautics concentration will no longer have to take ASE 3313 Incompressible Aerodynamics. Students in both concentrations will now have two technical electives, instead of just one. There will be parallel courses. ASE 3123 Aircraft Attitude Dynamics (in the Aeronautics concentration) and ASE 3823 Spacecraft Attitude Dynamics (in the Astronautics concentration) will look at the responses of aircraft and spacecraft to disturbances. Both of these courses will feed into the common ASE 4123 Aerospace Controls course. Aeronautics students will take ASE 4413 Aircraft Propulsion, dealing primarily with jet engines and propellers, and Astronautics students will take ASE 4423 Spacecraft Propulsion, dealing primarily with liquid- and solid-fueled rockets. Each concentration will have its own senior design sequence, ASE 4513/4523 Aircraft Design I & II for Aeronautics students and ASE 4533/4543 Spacecraft Design I & II for Astronautics students. Because of the knowledge of compressible flow needed for both jet and rocket engines, all students will take ASE 3333 Aerothermodynamics and ASE 4343 Compressible Aerodynamics. Because of the similarities in aircraft and space structures, all students will take a common aerospace structures sequence. The current sequence is ASE 3213 Aircraft Structures I, ASE 3223 Aircraft Structures II, and ASE 4623 Aircraft Structures III. These will be renamed Mechanics of Deformable Structures, Aerospace Structural Analysis, and Aerospace Structural Design, respectively, to more accurately reflect the specific content of the courses and the commonality of the subject matter to both the Aeronautics and Astronautics concentrations.

As stated above, each concentration will have two technical electives. The Department of Aerospace Engineering has decided to specify that any required course in one concentration, at the 3000 level or the 4000 level, will qualify as a technical elective for a student in the other concentration. This will give students the chance to broaden their education to include a significant portion of the fundamental material in the other concentration, if they so choose. This will also aid in the implementation of the two concentrations. We plan to begin the two concentrations in the Fall 2006 semester, requiring sophomores to declare a concentration in the spring of 2006, when they preregister for the fall (the first semester of their junior year). For students who will be seniors in the fall of 2006, they will have the option of declaring an Aeronautics concentration, which will mean they will simply replace ASE 3813 Introduction to Orbital Mechanics with a technical elective. If those students choose to declare an Astronautics concentration, they will be able to. We will count ASE 3123 and ASE 3313, which they will have already had, as their two technical electives. They will have to take ASE 3813 and ASE 3823 simultaneously with ASE 4533/4543, which will have ASE 3813 and ASE 3823 as prerequisites. If we have Fall 2006 seniors who wish to declare an Astronautics concentration, we will have to teach ASE 4533/4543 in such a way that it takes into account the fact that the students do not have the prerequisites but are taking them concurrently. This should not be a problem, since those Fall 2006 seniors will be the only ones in the course, and all students who come after them in ASE 4533/4543 will have already had the prerequisite courses.

Assessment

<u>Comparison with leading academic programs in the discipline</u>

Appendix A contains a listing for the aerospace engineering degree program at the University of Maryland, and Appendix B contains a listing of the degree program at the University of Texas at Austin. These are two of the most highly-regarded programs in aerospace engineering in the country, and these two programs, along with a number of other aerospace engineering programs, have offered aeronautics and astronautics concentrations for a number of years. In terms of the concentrations that we intend to offer, the proposed MSU ASE program follows these two programs closely. We are particularly close to the Maryland program; the course offerings in our two concentrations almost duplicate the offerings in Maryland's Aero and Astro tracks. The program at UT has a larger number of courses in its common program and fewer courses in its two Technical Areas (7 credit hours versus our 15 hours in concentrations). The general areas of study for our concentrations and UT's Technical Areas match up well, however. We also have a close correspondence with both programs in the courses common to both concentrations / tracks / technical areas. We believe that both our current and our proposed programs compare very well with these flagship programs.

Advisory Board review, assessment and feedback of the degree program

A summary of the modifications to the ASE curriculum that would result in the aeronautics and astronautics concentrations was circulated electronically to the members of the ASE Advisory Board, plus one alumnus of the Mississippi State University ASE program who currently works at NASA's Marshall Space Flight Center in Huntsville, Alabama. Of the individuals polled, many responded with comments. There were no direct objections to the proposed changes in the curriculum. Two of the respondents thought that the program should move into the area of rotorcraft. This is a possibility which will warrant further consideration. However, rotorcraft analysis and design is a topic that would fall under the aeronautics concentration, since rotorcraft are a type of aircraft, and we believe that an increased coverage of rotorcraft could be handled with additional technical electives within the aeronautics concentration, as faculty expertise and demand allow. All but one of the respondents that directly addressed the issue of aeronautics and astronautics concentrations were in favor of the proposed changes (the one respondent had what could be considered a negative response, expressing the opinion that more aircraft operations material should be introduced to the curriculum rather than more astronautics, but both aircraft and spacecraft operations could be addressed with the development of technical electives within the proposed concentrations as time and faculty expertise allow; this respondent did not address any of the proposed changes specifically). Some of the comments from the respondents are listed below:

"I reviewed the proposed changes to the Aero curriculum and find the Aero and Astro concentrations provide more focused course work in one of two potential career paths in Aerospace Engineering. I support this plan as proposed." *Dr. Richard Gilbrech, MSU ASE BS 1985; Deputy Director, NASA Engineering and Safety Center, NASA Langley Research Center*

"In general, I think it's good to broaden and strengthen the offerings in astro. Given NASA's emphasis on space initiatives and the de-emphasis on aeronautics, this may be very appropriate." *Rob Wolz, MSU ASE BS 1982; Director, Preliminary Design, Gulfstream Aerospace, A General Dynamics Company*

"In my opinion, this is an outstanding improvement in the curriculum and is probably long overdue. I truly wish that I'd had the opportunity to concentrate on Astronautics when I went through the program (1982-1986). I believe graduates will be much better prepared to participate in, and contribute to, the future of space exploration with the experience of this specialized coursework." *Ray Echols, MSU ASE BS 1986; International Space Station Payload Operations Director, NASA Marshall Spaceflight Center*

"I have reviewed your proposed curriculum, and I think dividing the curriculum into aeronautics and astronautics concentrations is a great idea. Also, you have the correct broad contents in each." *Dr. Danny Howard, MSU ASE BS 1990; Function Manager, ACS Sensor/Actuator Subsystem Engineering, Boeing Satellite Systems.*

"I believe that it is appropriate to offer both an aeronautics and astrodynamics option. My concern with the proposed astrodynamics curriculum is that I only count 4 courses in the specialty that are unique to it. Having spent my entire career in space launch systems, I believe that is not a very strong lineup. There is an awful lot more involved, not all of which I know you cannot offer and give a complete engineering education. But you might want to consider introductory courses in space launch vehicles and operations, aerospace telemetry fundamentals, introductory to guidance systems, mandatory basic course in microcircuits, and introduction to launch vehicle/spacecraft integration (big plus). These would make the student conversant and equipped to work in the industry." *Victor Whitehead, MSU AE BS 1961; retired; formerly Vice President, Space Launch Systems, Lockheed Martin Astronautics*

(Response to comments by Mr. Whitehead: There are 5 courses specific to each of the two concentrations. The spacecraft design sequence will address some issues related to space launch vehicles, as well as the spacecraft propulsion course. Students in the Astronautics concentration will take a controls course which will serve at least to some degree as an introduction to guidance systems. The spacecraft design sequence will also address some issues related to aerospace telemetry and launch vehicle / spacecraft integration. The only topic in Mr. Whitehead's list that is not addressed to at least some degree in the proposed Astronautics curriculum is the course in microcircuits, which is not an area of expertise for the ASE faculty. We can suggest to our students in the Astronautics curriculum that they take an appropriate course in Electrical and Computer Engineering as one of their two technical electives.)

Note: Carrie Olsen (a co-author of this paper), Assistant Professor of Aerospace Engineering, contributed significantly to the development of the Astronautics concentration presented in this proposal. Dr. Olsen is an alumna of the MSU ASE program (BS 1985, MS 1986) who worked for NASA Marshall Spaceflight Center for over 17 years as a Payload Operations Specialist and Flight Director for various NASA space operations, including Space Shuttle and International Space Station missions. She completed a Ph. D. in Orbital Mechanics from the University of Texas at Austin in 2001 and joined the ASE faculty at MSU in the fall of 2004.

Discussion of other issues/questions required for Mississippi State University curriculum approval

<u>This program change meets local, state, regional, and national educational and cultural needs.</u> We believe that the proposed program changes will meet a particular need for engineers trained in astronautics. There is currently a new national emphasis on space exploration, and new space technology industries are beginning to locate in Mississippi. We believe that the proposed astronautics concentration will assist in meeting the expected increase in demand for engineers trained in the analysis and design of space vehicles and space systems.

<u>This program change cannot result in duplication in the Mississippi Institutions of Higher Learning system.</u> This change will not result in any duplication in the System. The MSU Department of Aerospace Engineering was the only department offering courses in astrodynamics and rocket propulsion from an engineering perspective, and the proposed concentration in astronautics will merely expand on these offerings.

<u>This program change will advance student diversity within the discipline.</u> We believe that the proposed concentration in astronautics will increase the diversity of the aerospace engineering student population. We will appeal to a broader student population in general because of the added subject material. We will now attract those students who were interested in space but not necessarily interested in airplanes. NASA has gone to considerable effort to appeal to women and minorities. The vision statement for the NASA Office of Diversity and Equal Opportunity reads as follows: "***NASA will set the Equal Opportunity Standard for Excellence through a highly skilled workforce which is representative, at all levels, of America's diversity and built upon trust, respect, teamwork, communication, empowerment and commitment in an environment which is free of discrimination.***" NASA's efforts in this area have resulted in a percentage of engineers from underrepresented groups working at NASA that is significantly higher than the overall national percentage. By offering a concentration at MSU that will prepare students for careers at NASA and in the space industry in general, we will be in a position to capitalize on NASA's efforts to draw underrepresented groups into the space industry, and so we have every reason to expect an increase in the diversity of the ASE student population.

<u>This program change will result in an increase in the potential placement of graduates in Mississippi, the Southeast, and the U. S.</u> We believe that the addition of the astronautics option will increase the potential for our graduates to find positions after graduation. As discussed above, there has been a renewed emphasis in the U.S. on space exploration, and companies who are developing the technologies necessary for new space exploration will need engineers trained in astronautics. There is also continued growth in the area of space utilization for telecommunications, imaging, weather forecasting, and other fields, and the companies and manufacturers involved in these areas, such as the design and construction of earth satellites, need engineers trained in astronautics. Stennis Space Center, is the primary engine test facility for NASA, and the increase in space exploration activity will no doubt lead to increased work at Stennis. ATK, a company that manufactures rocket booster parts, has been located in Mississippi for a few years. MilTec Missiles and Space has recently located an operation in Mississippi and has begun to do missile work for the U. S. Army. As a result of these and other

developments, it is increasingly more likely that a student with a degree in aerospace engineering with a concentration in astronautics will be able to find a job in the space industry here in Mississippi.

This program change will result in an increase in the potential salaries of graduates in Mississippi, the Southeast, and the U. S. The proposed program change will result in an increase in potential salaries to the extent that salaries for engineers tend to be higher than average salaries, and so the increase in the number of graduates who can find a job because of their concentration in astronautics will lead to an increase in salaries overall.

This program change requires no additional support. The Department of Aerospace Engineering has recently hired two faculty members, one with experience in spacecraft operations and the other in spacecraft design. It is the addition of these two faculty members that has provided the opportunity to offer a true astronautics concentration.

Conclusions

Though the actual impact of these curriculum changes will not be clear for several years, or in fact for several cycles of peak demand in aeronautical and space industries, it was considered essential to present the rationale for this change to a two-track curriculum. Through discussions of these considerations, and through the adoption of an active plan for continuing to meet ongoing needs, this department will undoubtedly improve fulfillment of its obligation to its constituents, both students and industry.

References:

1. Mission objectives, Mississippi State University http://ae.Mississippi State University.edu/pages/Mission.pdf
2. Rais-Rohani, M., Koenig, K., Hannigan, T., "Keeping Students Engaged: An Overview of Three Introductory Courses in Aerospace Engineering", Proceedings of the 2003 ASEE Annual Conference & Exposition, Nashville, TN, June 2003.
3. Criteria for Accrediting Engineering Programs, ABET Engineering Accreditation Commission http://www.abet.org/forms.shtml (Engineering Accreditation Criteria)
4. NASA Vision Statement, http://www.hq.nasa.gov/office/codee/vision.html

Appendix A – B. S. program in Aerospace Engineering, University of Maryland

Audit for Aerospace Engineering (Admitted Fall 04 & after) Name and SS#: ______________________

Academic Year	Semester	Course Number	Course Name	Cr	Gr
Freshman 30 credits	Fall	ENES 100	Introduction to Engr. Design	3	
		ENAE 100	The Aerospace Engineering Profession	1	
		CHEM 135	General Chemistry for Engineers	3	
	*ENGL 101 should be taken during the first year	MATH 140	Calculus I	4	
		CORE *		3	
	Spring	ENES 102	Statics	3	
		ENAE 202	Aerospace Computing	3	
		MATH 141	Calculus II	4	
		PHYS 161	General Physics: Mech. And Part. Dyn.	3	
		CORE *		3	
Sophomore 33 credits	Fall	ENES 220	Mechanics of Materials	3	
		ENAE 283	Introduction to Aerospace Systems	3	
		MATH 241	Calculus III	4	
		PHYS 260/261	General Physics:Vib., Wvs., Heat, Elc., & Mag.	4	
		CORE		3	
	Spring	ENME 232	Thermodynamics	3	
		MATH 240	Introduction to Linear Algebra	3	
		MATH 246	Differential Equations for Scientists & Engrs.	3	
		PHYS 270/271	General Physics: Elc.dyn., Light, Rel., & Mod.	4	
		CORE		3	
Junior 31 credits	Fall	ENAE 311	Aerodynamics I	3	
		ENAE 301	Dynamics of Aerospace Systems	3	
		ENAE 204	Software Toolbox	3	
		ENAE 362	Aerospace Instrumentation & Experimentation	3	
		CORE		3	
	Spring	ENAE 324	Aerospace Structures	4	
		ENAE 432	Control of Aerospace Systems	3	
		ENGL 393	Technical Writing	3	
		CORE		3	
	AERO TRACK:	ENAE 414	Aerodynamics II	3	
	ASTRO TRACK:	ENAE 404	Space Flight Dynamics	3	
Senior 30 credits	Fall	ENAE 464	Aerospace Engineering Lab	3	
** Dependent upon coursework completed in CORE		**CORE or Elective		3	
	AERO TRACK:	ENAE 403	Aircraft Flight Dynamics	3	
		ENAE 455	Aircraft Propulsion and Power	3	
		ENAE 481	Principles of Aircraft Design	3	
	ASTROTRACK:	ENAE 441	Space Navigation and Guidance	3	
		ENAE 457	Space Propulsion and Power	3	
		ENAE 483	Principles of Space Systems Design	3	
	Spring	ENAE 423	Vibration and Aeroelasticity	3	
		**CORE or Elective		3	
		Aerospace Elective		3	
		Technical Elective		3	
	AERO TRACK: *(Capstone)*	ENAE 482	Aeronautical Systems Design	3	
	ASTRO TRACK: *(Capstone)*	ENAE 484	Space Systems Design	3	

Reviewed by Faculty Advisor ______________________ Date: __________ (Revised 12/11/03)

REFFERRED BY ADVISOR FOR FURTHER DEPARTMENTAL REVIEW: Y/N ______________________

Total credits must be ≥124

University of Maryland Aerospace Engineering courses (ENAE prefix; equivalencies are to *new* or *modified* MSU ASE courses, except where noted):

Courses required of all UMD AE students

100 The Aerospace Engineering Profession (material contained in ASE 1013 Intro. To Aerospace Engineering)
202 Aerospace Computing (material contained in ASE 1013/1023/2013)
283 Introduction to Aerospace Systems (equivalent to ASE 1013/1023/2013)
311 Aerodynamics I (equivalent to ASE 4343 Compressible Aerodynamics)
301 Dynamics of Aerospace Systems (equivalent to EM 2413 Engineering Mechanics II)
203 Software Toolbox (no direct equivalent)
362 Aerospace Instrumentation and Experimentation (equivalent to ASE 4113 Aerospace Engineering Laboratory I)
324 Aerospace Structures (equivalent to ASE 3213 Aircraft Structures I)
432 Control of Aerospace Systems (equivalent to ASE 4123 Aerospace Vehicle Controls)
464 Aerospace Engineering Lab (equivalent to ASE 4721 Aerospace Engineering Laboratory II)
423 Vibration and Aeroelasticity (vibrations material equivalent to EM 3413 Vibrations; no equivalent to aeroelasticity material)

Aero track courses

414 Aerodynamics II (equivalent to ASE 3313 Incompressible Aerodynamics)
403 Aircraft Flight Dynamics (equivalent to ASE 3123 Aircraft Attitude Dynamics)
455 Aircraft Propulsion and Power (equivalent to ASE 4413 Aircraft Propulsion)
481 Principles of Aircraft Design (equivalent to ASE 4513 Aircraft Design I)
482 Aeronautical Systems Design (equivalent to ASE 4523 Aircraft Design II)

Astro track courses

403 Space Flight Dynamics (material equivalent to ASE 3813 Intro. To Orbital Mechanics and ASE 3823 Spacecraft Attitude Dynamics)
441 Space Navigation and Guidance (material equivalent to ASE 3813 Intro. To Orbital Mechanics and ASE 4813 Advanced Orbital Mechanics, an ASE technical elective)
455 Space Propulsion and Power (equivalent to ASE 4423 Spacecraft Propulsion)
481 Principles of Space System Design (equivalent to ASE 4533 Spacecraft Design I)
484 Space Systems Design (equivalent to ASE 4543 Spacecraft Design II)

Appendix B – B.S. program in aerospace engineering, University of Texas at Austin

Curriculum (taken from the UT online catalog for 2004-2005)
Course requirements are divided into three categories: basic sequence courses, major sequence courses, and other required courses. Enrollment in major sequence courses is restricted to students who have received credit for all of the basic sequence courses and have been admitted to the major sequence by the College of Engineering Admissions Committee. (Requirements for admission to a major sequence are given in this chapter.) Enrollment in other required courses is not restricted by completion of the basic sequence.

Courses used to fulfill technical and nontechnical elective requirements must be approved by the aerospace engineering faculty before the student enrolls in them. Courses that fulfill the social science and fine arts/humanities requirements are listed in this chapter.

Courses	Semester Hours
Basic Sequence Courses	
Aerospace Engineering 201, 102, 211, Chemistry 301, Engineering Mechanics 306, 311M, 319, English 316K, Mathematics 408C, 408D, 427K, 427L, Physics 303K, 303L, 103M, 103N, Rhetoric and Composition 306	47
Major Sequence Courses	
Aerospace Engineering 320, 120K, 321K, 324L, 330M, 333T, 340, 463Q, 365, 366K, 367K, 167M, 369K, 370L, 376K	42
Technical area courses	7
Approved technical electives	6
Other Required Courses	
Electrical Engineering 331K, Mechanical Engineering 210, 326	8
American government, including Texas government	6
American history	6
Approved social science elective	3
Approved fine arts or humanities elective	3
Minimum Required	128

Technical Area Options
The technical area option allows the student to choose seven semester hours of technical area courses in either atmospheric flight or space flight. Each student should choose a technical area

by the end of the first semester of the junior year and plan an academic program to meet the area requirements in the next three semesters. Many students choose technical electives that will strengthen their backgrounds in one specialty area, but this is not required. It should be noted that a student may choose the technical area courses in the other technical area as electives and that, with the addition of only one semester hour beyond the minimum number required, the student can complete all required courses in both technical areas. This route provides a greater emphasis on the design process and gives students more flexibility in the job market.

Area 1, Atmospheric Flight
Also called aeronautics, this area provides the student with a well-rounded program of study emphasizing the major disciplines of aerodynamics, propulsion, structures, design, performance, and control of aircraft. These subjects are treated at a fundamental level that lays a foundation for work in a broad variety of specialties in the aircraft industry. This option is intended for the undergraduate student whose primary interest is aircraft.

Aerospace Engineering 362K, *Compressible Fluid Mechanics*
Aerospace Engineering 162M, *Applied Compressible Fluid Mechanics*
Aerospace Engineering 261K, *Aircraft Design*
Aerospace Engineering 161M, *Aircraft Design Laboratory*

Area 2, Space Flight
Also called astronautics, this area offers a well-rounded program of study that provides a background in the traditional areas of fluid mechanics, materials, structures, propulsion, controls, and flight mechanics, while also giving the student a chance to learn about the space environment, attitude determination and control, orbital mechanics, mission design, and spacecraft systems and design. These subjects are treated at a fundamental level that lays a foundation for work in a broad variety of specialties in space-related industries. This option is intended for the undergraduate student whose primary interest is space and spacecraft.

Aerospace Engineering 166M, *Space Applications Laboratory*
Aerospace Engineering 372K, *Advanced Spacecraft Dynamics*
Aerospace Engineering 274L, *Spacecraft/Mission Design Principles*
Aerospace Engineering 174M, *Spacecraft/Mission Design Laboratory*

UT Aerospace Engineering courses (required of all UT ASE majors in both areas; equivalencies are to *new* or *modified* MSU ASE courses, except where noted):

102 Introduction to Aerospace Engineering (equivalent to ASE 1013 Intro to ASE)
201 Introduction to Computer Programming (material covered in ASE 1013/1023/2013)
211 Engineering Computation (material covered in ASE 1013/1023/2013)
320 Introduction to Fluid Mechanics (equivalent to ASE 3313 Incompressible Aerodynamics)
120K Applications of Fluid Mechanics (wind tunnel laboratory course)
321K Structural Analysis (equivalent to ASE 3213 Aircraft Structures I)
324L Aerospace Materials Laboratory (equivalent to some material in ASE 4623 Aircraft Structures III)

330M Linear Systems Analysis (no direct equivalent; intermediate course between EM 3413 Vibrations and ASE 4123 Aerospace Vehicle Controls)
333T Engineering Communication (equivalent to GE 3513 Technical Writing)
340 Boundary Layer and Heat Transfer (no direct equivalent)
463Q Design and Testing of Aerospace Structures (equivalent to ASE 4623 Aircraft Structures III)
365 Structural Dynamics (no direct equivalent)
366K Spacecraft Dynamics (equivalent to material in ASE 3813 Intro. To Orbital Mech. And ASE 3823 Spacecraft Attitude Dynamics)
367K Flight Dynamics (equivalent to ASE 3123 Aircraft Attitude Dynamics)
167M Flight Dynamics Laboratory (no direct equivalent)
369K Measurements and Instrumentation (equivalent to ASE 4113 Aerospace Engineering Laboratory I)
370L Flight Control Systems (equivalent to ASE 4123 Aerospace Vehicle Controls)
376K Propulsion (equivalent to ASE 4413 Aerospace Propulsion, old version)

Informal Notes on Various Aerospace Engineering Curricula

Appendix C -- Informal Notes on Various Aerospace Engineering Curricula

The University of Alabama

Department of Aerospace Engineering and Mechanics. One curriculum. 2-semesters of senior design. Aircraft and/or spacecraft covered. No specific space courses required. Have 2 as electives – Orbital Mechanics and Spacecraft Dynamics. General note: Their curriculum has a strong emphasis on computing/algorithm development.

Auburn University

Department of Aerospace Engineering. Curriculum has Orbital Mechanics in the 2nd semester of the junior year. Have a choice of Space or Aircraft Design (2 semester course for both). Also offer a Space Systems course.

The US Air Force Academy

Two separate degree programs are offered: Aeronautical Engineering and Astronautical Engineering. These begin to diverge in the Sophomore year. For Astronautics: Intro to Astronautics (Soph), Astrodynamics (Jun.) and Rocket Propulsion (Sen.) are required and many elective courses are listed (9). It is not known how often each is taught, but the list is impressive. “Space Mission Design” is the design class title instead of the more usual Spacecraft or Space Systems Design.

The US Naval Academy

Two separate degree programs just like USAFA. Aeronautics and Astronautics. The split starts at the beginning of the Junior year when the astronautics students take Astrodynamics (fall) and Spacecraft Attitude Dynamics and Control (spring). The senior year is full of specialized courses (only one technical elective): Space Environment, Spacecraft Thermal Control, Space Power and Communications, Spacecraft Systems Lab and Spacecraft Vehicle Design.

Note: Both military academy programs are highly specialized. Also, since so many humanities, military and political science courses are required, some of the basic engineering courses are covered earlier than usual and many are combined. (Engineering mechanics, structures, etc.)

Kansas University

Small department. One concentration; very similar to our curriculum; heavy aircraft emphasis. Students do get a choice between Space Systems Design and Aircraft Systems Design. There are 9 hours of technical electives – only one has to be in the aerospace department. They also teach a class called Spacecraft Systems that is probably a precursor for design. It has astrodynamics imbedded in it, but it is only a small part. The class covers a lot of territory – overview of all the systems in a typical spacecraft.

The University of Notre Dame

Department is called "Aerospace and Mechanical Engineering" so, predictably, there is only one aerospace concentration and only one design class. Not sure if it is always aircraft or if it varies. There are 9 hours for "specialization" and 1 required orbital mechanics class like [university] has now. However, they list quite a few space classes that undergraduates may choose from: Intermediate Dynamics (not truly just space), Space Systems Analysis, Space Environments, Attitude Determination and Control, Space Power, and Telecommunications.

The University of Florida

Department name is "Mechanical and Aerospace Engineering". You can earn a dual degree in both with one extra semester. There is no aeronautics/astronautics split. The aerospace curriculum requires 1 aerodynamics class, 1 astrodynamics class, 1 stability and control of aircraft class and 1 controls class.

Florida State University

No aerospace curriculum offered.

University of Central Florida

"Department of Mechanical, Materials and Aerospace Engineering" – one aerospace concentration track and it is geared toward aeronautics.

North Carolina State University

Mechanical and Aerospace is combined and the aerospace is mostly aeronautical.

University of North Carolina

Small engineering "department", no aerspace concentration found.

University of Tennessee and U.T. – Space Institute

Both have departments of "Mechanical, Aerospace and Engineering Sciences". Both very weighted to fluids, aeronautics, thermodynamics and propulsion.

University of Virginia

Have a Mechanical and Aerospace Engineering department. They do offer an aerospace engineering degree. The required astrodynamics class appears to be the only class that is specifically geared toward astronautics.

Virginia Tech

Department of Aerospace and Ocean Engineering. They offer degrees in aerospace and ocean engineering or a combination of the two. There is only one aerospace concentration but there are 2 specific astronautics classes listed – Astromechanics (orbits) and Space Dynamics and Control (attitudes).

The University of Michigan

The Department of Aerospace Engineering at UM takes an interesting approach. There are indeed 2 design sequences – one for aircraft and one for space systems, but most of their departmental courses encompass both aircraft and spacecraft issues. For instance, they have Performance of Aircraft and Spacecraft, Aircraft and Spacecraft Structures, Aircraft and Spacecraft Propulsion, Flight Dynamics of Aerospace Vehicles. UM seems to combine spacecraft and aircraft material in a large number of courses instead of splitting things out. They also offer a Space Environments class and several aircraft-specific ones.

The University of Illinois

The Department of Aerospace Engineering does not have a dual track but there are a number of space courses to choose from in building their 134-semester hour curriculum. They have 2 design series options and a number of courses that seem to cover aircraft and spacecraft issues. But, the Orbital Mechanics and Spacecraft Attitude Control courses are senior electives. U of I has a large faculty, many involved in space research and a large list of undergraduate and graduate courses.

Georgia Tech

Private university. One program. Two-semester design curriculum with a choice of spacecraft or aircraft. Astrodynamics is an elective.

Penn State University

Department of Aerospace Engineering. 1 concentration. (137 hours total, required). Two different Design tracks – Spacecraft and Aircraft (2 semesters each). Space related undergraduate courses: Space Science and Technology (an introductory class), Astronautics, Space Propulsion and Power Systems, Orbit and Attitude Control of Spacecraft, Space Astronomy and Introduction to Space Science. 9 hours of technical electives in the senior year.

Ohio State University

Department of Aerospace Engineering (used to be Aerospace Engineerin and Aviation until this year). One concentration. One 3-quarter design sequence which may involve either a space vehicle or aircraft design. Orbital Mechanics in an elective.

University of Washington

Department of Aeronautics and Astronautics. (180 quarter hours). Two quarters of design and students may choose between space and aircraft. There is an Orbital and Space Flight Mechanics course and a number of space-related optional courses. An apparent emphasis in the department on controls and plasma.

University of Maryland

A true 2-concentration curriculum which begins in the junior year. Number of choices: Aerodynamics II or Space Flight Dynamics; Aircraft Flight Dynamics or Space Navigation and Guidance; Aircraft or Spacecraft Propulsion and Power and Aircraft or Space Systems Design (2 semesters).

University of Texas at Austin

Department of Aerospace Engineering and Engineering Mechanics. 2-concentration system. Students apply for a "major sequence" at the completion of the "basic sequence" (freshman and sophomore years) – Atmospheric Flight or Space Flight. The "split" doesn't really occur until senior year (Spacecraft Dynamics is required of everyone in the fall of junior year.) In the senior year 7 hours of "technical area courses" and 6 hours of technical electives are used to produce the specialization. It is a 128-hour degree program. The following is the list of what produces the 7 hours of technical area courses for each track.

Atmospheric	Space
Compressible Fluid Mech.	Space Applications Lab.
Applied Compressible Fluid Mech.	Advanced Spacecraft Dynamics
Aircraft Design	Spacecraft/Mission Design Principles
Aircraft Design Lab.	Spacecraft/Mission Design Lab.

There is an extensive list of technical electives to choose from on both sides – owing to the size of the department and the faculty.

Texas A&M University

This Department of Aerospace Engineering has a very traditional "aeronautics" curriculum (much like [university]) with one orbital mechanics class (Space Technology I) in the senior year. There does not appear to be a choice in capstone design. Only a small number of space-related technical electives were found. Most space-related courses seem to be concentrated in the graduate program.

Purdue University

The Department of Aeronautics and Astronautics has two concentrations. The "split" begins at the end of the junior year. The choices are 1) Aerodynamics lab or structures lab, 2) Jet Propulsion or Rocket Propulsion, 3) Aircraft Design or Spacecraft Design (2 semesters) and 4) Flight Dynamics and Control or Spacecraft Attitude Dynamics. There are 6 hours of technical electives and 15 hours of major/minor area electives in the senior year. There is an extensive list of courses to choose from for either concentration.

The University of Colorado

The Department of Aerospace Engineering Sciences does not formally offer two concentrations, but there are 12 hours of "professional area electives" in the senior year. All students are required to take a 4-semester hour course in Orbital Mechanics and Attitude Dynamics and Control. There are two required courses called "Senior Projects 1 and 2" which are apparently the design courses. It is not clear that there is a choice in the subject area of these. There are also elective course in Aircraft Design, Spacecraft Design and Space Habitat Design. The Univ. of Colorado is somewhat unique in the types of electives they have to offer in astronautics. Some examples are: Intro to Space Experimentation, Intro to Biomedical Engineering, Intro to Space Dynamics, Neural Systems, Satellite Geodesy and Spacecraft Life Support Systems.