

Department:	Aerospace	
Programs:	BSAE / MSAE	
College:	Engineering	
Program Website	BSAE: www.sjsu.edu/ae/programs/bsae MSAE: www.sjsu.edu/ae/programs/msae	
Link to Program Learning Outcomes (PLOs) on program website:	BSAE: www.sjsu.edu/ae/programs/bsae/bsae_program_outcomes MSAE: www.sjsu.edu/ae/programs/bsae/msae_program_outcomes	
Program Accreditation (if any):	ABET (BSAE)	
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Date of Report:	01 March 2017	

Part A

1. List of Program Learning Outcomes (PLOs): No changes¹

1A. - **BSAE Program Learning Outcomes** are specified by ABET. AE faculty have broken down each outcome into elements and proposed performance criteria for each outcome element.

Outcome A: Ability to use mathematics, science, and engineering principles to identify, formulate and solve aerospace engineering problems.

Outcome Elements

A-1: Apply mathematics.

A-2: Apply physics.

A-3: Apply aerospace engineering principles.

A-4: Identify, formulate and solve aerospace engineering problems.

A-1: Ability to apply mathematics

Outcome Performance Indicators:

A-1.1: Apply calculus.

A-1.2: Derive and solve differential equations.

A-1.3: Use linear algebra.

A-2: Ability to apply physics

Outcome Performance Indicators:

A-2.1: Draw free-body diagrams.

A-2.2: Apply Newton's laws/physics concepts (e.g. angular momentum, friction, etc.).

¹ "Performance Criteria" have been renamed "Performance Indicators", as suggested in the Annual Assessment Feedback (January 2017), to be consistent with ABET language.

A-3: Ability to apply engineering principles*Outcome Performance Indicators:*

- A-3.1: Apply aerospace structures principles.
- A-3.2: Apply aerospace dynamics principles.
- A-3.3: Apply aerodynamics principles.
- A-3.4: Apply flight mechanics principles.
- A-3.5: Apply aerospace propulsion principles.
- A-3.6: Apply stability and control principles.

A-4: Ability to identify, formulate and solve AE problems*Outcome Performance Indicators:*

- A-4.1: Engage in the solution of problems (spend adequate time on task, ask questions, etc.).
- A-4.2: Define (open-ended) problems in appropriate engineering terms.
- A-4.3: Explore problems (i.e., examine various issues, make appropriate assumptions, etc.).
- A-4.4: Develop a plan for the solution (i.e., select appropriate theories, principles, approaches).
- A-4.5: Implement their solution plan and check the accuracy of their calculations.
- A-4.6: Evaluate their results and reflect on their strengths and weaknesses in the process.

Outcome B: Ability to design and conduct water tunnel and wind tunnel experiments, as well as to analyze and interpret data from such experiments.

Outcome Elements

- B-1: Design water tunnel and wind tunnel experiments.
- B-2: Conduct water tunnel and wind tunnel experiments.
- B-3: Analyze data from water tunnel and wind tunnel experiments.
- B-4: Interpret data from water tunnel and wind tunnel experiments.

B-1: Ability to design experiments*Outcome Performance Indicators:*

- B-1.1: Define goals and objectives for the experiment.
- B-1.2: Research relevant theory and published data from similar experiments.
- B-1.3: Select the dependent and independent variables to be measured.
- B-1.4: Select appropriate methods for measuring/controlling each variable.
- B-1.5: Select a proper range for the independent variables.
- B-1.6: Determine an appropriate number of data points for each type of measurement.

B-2: Ability to conduct experiments.*Outcome Performance Indicator:*

- B-2.1: Given an experimental setup, become familiar with the equipment, calibrate the instruments to be used, and follow the proper procedure to collect the data.

B-3: Ability to analyze data from experiments.*Outcome Performance Indicator:*

- B-3.1: Given a set of experimental data, carry out the necessary calculations and tabulate / plot the results using appropriate choice of variables and software.

B-4: Ability to interpret data from experiments.*Outcome Performance Indicators:*

- B-4.1: Given a set of results in tabular or graphical form, make observations and draw conclusions regarding the variation of the parameters involved.
- B-4.2: Given a set of results in tabular or graphical form, compare with theoretical

predictions and/or other published data and explain any discrepancies.

Outcome C: Ability to perform conceptual and preliminary design of aircraft or spacecraft to meet a set of mission requirements within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Outcome Performance Indicators:

- C-1: Research, evaluate, and compare vehicles designed for similar missions.
- C-2: Follow a prescribed process to develop the conceptual/preliminary design of an aerospace vehicle.
- C-3: Develop economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints and design a vehicle that meets these constraints.
- C-4: Select an appropriate configuration for an aerospace vehicle with a specified mission.
- C-5: Apply AE principles (ex. aerodynamics, structures, flight mechanics, propulsion, stability and control) to design various vehicle subsystems.
- C-6: Develop and compare alternative configurations for an aerospace vehicle, considering trade-offs and appropriate figures of merit.
- C-7: Develop final specifications for an aerospace vehicle.

Outcome D: Ability to collaborate with people from different cultures, abilities, backgrounds, and disciplines to complete aerospace engineering projects.

Outcome Performance Indicators:

- D-1: Participate in making decisions, negotiate with partners, and resolve conflicts arising during teamwork.
- D-2: Set goals related to team projects, generate timelines, organize and delegate work among team members, and coach each other as needed to ensure that all tasks are completed.
- D-3: Demonstrate leadership by taking responsibility for various tasks, motivating and disciplining others as needed.
- D-4: Demonstrate adequate understanding of other fields (e.g. different branches of engineering / physical sciences, economics, management, etc.) to participate effectively on multidisciplinary projects.
- D-5: Communicate ideas relating to AE in terms that others outside the discipline can understand.

Outcome E: Ability to communicate effectively through technical reports, memos, and oral presentations as well as in small group settings.

Outcome Elements

- E-1: Communicate in writing
- E-2: Communicate orally

E-1: Ability to communicate in writing

Outcome Performance Indicators:

- E-1.1: Produce well-organized reports, following guidelines.
- E-1.2: Use clear, correct language and terminology while describing experiments, projects or solutions to engineering problems.
- E-1.3: Describe accurately in a few paragraphs a project / experiment performed, the procedure used, and the most important results (abstracts, summaries).
- E-1.4: Use appropriate graphs and tables following published engineering standards to present results.

E-2: Ability to communicate orally*Outcome Performance Indicators:*

- E-2.1: Give well-organized presentations, following guidelines.
- E-2.2: Make effective use of visuals.
- E-2.3: Present the most important information about a project / experiment, while staying within allotted time.
- E-2.4: In small group settings, listen carefully, ask clarifying questions when others speak, and respect the opinion of others when disagreeing.

Outcome F: Understanding of professional and ethical responsibility.

Outcome Elements

- F-1: Understanding of professional responsibility.
- F-2: Understanding of ethical responsibility.

F-1: Understanding of professional responsibility.*Outcome Performance Indicators:*

- F-1.1: Demonstrate professional excellence in performance, punctuality, collegiality, and service to the aerospace engineering profession.

F-2: Understanding of ethical responsibility.*Outcome Performance Indicators:*

- F-2.1: Are aware of the various professional codes of ethics (e.g. NSPE, ASME).
- F-2.2: Properly acknowledge the work of others by citing all their sources when writing reports.
- F-2.3: Given a job-related scenario that requires a decision with ethical implications they can identify possible courses of action, discuss the pros and cons of each one, decide on the best course of action, and justify their decision.

Outcome G: Broad education to understand current events, how they relate to aerospace engineering, as well as the impact of engineering solutions in a global and societal context.

Outcome Performance Indicators:

- G-1: Identify regional, national, or global contemporary problems that involve AE.
- G-2: Discuss possible ways AE could contribute to the solution of these problems.
- G-3: Describe accurately the environmental impact of aerospace vehicles, including those they have designed in course projects.
- G-4: Describe accurately the health / safety impact of aerospace vehicles, including those they have designed in course projects.

Outcome H: Recognition of the need for, and ability to engage in life-long learning.

Outcome Elements

- H-1: Recognition of the need for lifelong learning.
- H-2: Ability to engage in lifelong learning.

H-1: Recognition of the need for lifelong learning*Outcome Performance Indicators:*

- H-1.1: Willing to learn new material on their own.
- H-1.2: Participate in professional societies.
- H-1.3: Read non-course related AE related articles / books, attend short courses, workshops, seminars, conferences and plan to attend graduate school.

H-2: Ability to engage in lifelong learning.*Outcome Performance Indicators:*

- H-2.1: Develop a systematic approach to studying a new topic, reflect regularly on their learning process and make any necessary adjustments to improve the efficiency of this process.
- H-2.2: Access information effectively and efficiently from a variety of sources (e.g. articles, books, experts, etc.) and learn new material on their own.

Outcome I: Ability to use the techniques, skills, and modern engineering tools (analytical, experimental, and computational) necessary for aerospace engineering practice.

Outcome Performance Indicators:

- I-1: Access information effectively and efficiently from the internet.
- I-2: Use state-of-the-art software to write technical reports and give oral presentations.
- I-3: Use computer simulations to conduct parametric studies and ‘what if’ explorations.
- I-4: Use modern software to analyze aerospace systems.
- I-5: Use modern equipment and instrumentation in AE laboratories.
- I-6: Are aware of state-of-the-art tools and practices used in the aerospace industry through plant visits and presentations by practicing engineers.

GE Area S: Self, Society, and Equality in the US

- S-LO1: Describe how identities (i.e. religious, gender, ethnic, racial, class, sexual orientation, disability, and/or age) are shaped by cultural and societal influences within contexts of equality and inequality.
- S-LO2: Describe historical, social, political, and economic processes producing diversity, equality, and structured inequalities in the U.S.
- S-LO3: Describe social actions which have led to greater equality and social justice in the U.S. (i.e. religious, gender, ethnic, racial, class, sexual orientation, disability, and/or age).
- S-LO4: Recognize and appreciate constructive interactions between people from different cultural, racial, and ethnic groups within the U.S.

GE Area V: Culture, Civilization, & Global Understanding

- V-LO1: Compare systematically the ideas, values, images, cultural artifacts, economic structures, technological developments, and/or attitudes of people from more than one culture outside the U.S.
- V-LO2: Identify the historical context of ideas and cultural traditions outside the U.S. and how they have influenced American culture
- V-LO3: Explain how a culture outside the U.S. has changed in response to internal and external pressures.

BSAE PLO performance targets are defined as follows:

The scores earned by all students, in the assignments and test questions, which pertain to a particular performance indicator, in each course where this performance indicator is assessed, must be at least 70% to ensure working knowledge of the material.

1.B- AE faculty have proposed the following **MSAE Program Learning Outcomes** with input from the AE Advisory Board.

Outcome A: Ability to use graduate level mathematics to model and solve aerospace engineering problems.

Outcome B: Ability to apply aerospace engineering science (aerodynamics, propulsion, flight mechanics, stability & control, aerospace structures & materials, etc.) to perform an in-depth analysis and / or design of an aerospace engineering system taking into consideration economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints.

Outcome C: Ability to use modern tools (computational or experimental).

Outcome D: Ability to perform a literature search related to a given problem, cite the references in appropriate ways, and demonstrate an understanding of the cited literature.

Outcome E: Graduate level technical writing ability, including correct language and terminology, appropriate visuals, and summarizing key ideas.

Outcome A is assessed in AE200, a required course in the MSAE Program.

Outcomes B through E are assessed in students' final project/thesis reports, using the form below:

MSAE Thesis / Project Evaluation Form

Title							
Name		Semester –					
Advisor							
MSAE Outcomes / Outcome Elements		Max Possible	Ave score	Min Passing	Project Advisor	Faculty Member 2	Faculty Member 3
B.1	Application of AE science (aerodynamics, propulsion, flight mechanics, stability & control, aerospace structures & materials, etc.)	20		14			
B.2	In-depth analysis and/or design of an aerospace system or vehicle.	20		14			
C	Application of modern tools (computational or experimental)	10		7			
D.1	Appropriate literature search (# and appropriateness of references cited)	10		7			
D.2	Understanding of the cited literature (summary of previous work)	10		7			
E.1	Correct language and terminology	20		14			
E.2	Appropriate use of graphs and tables	10		7			
Total Score		100		70			

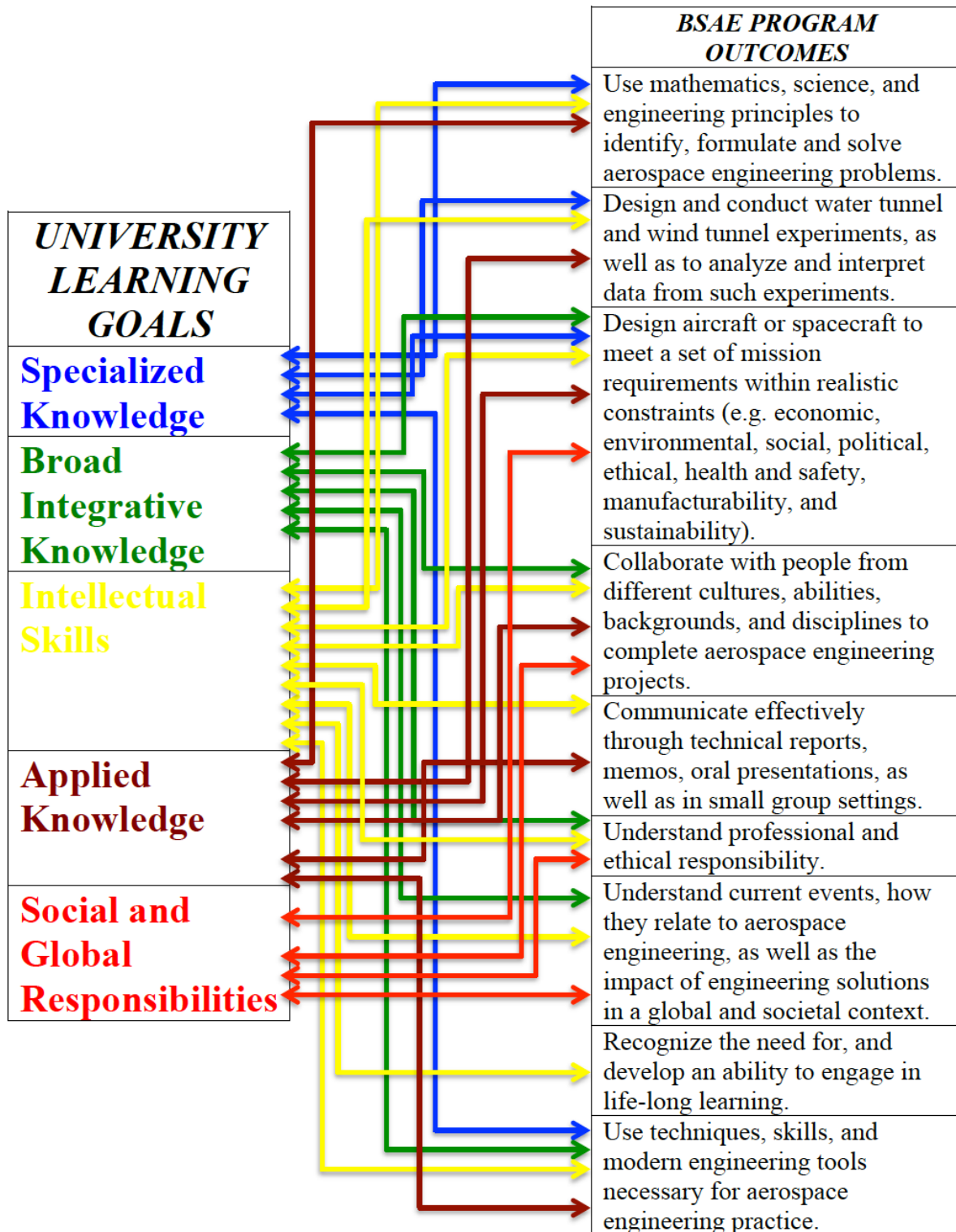
Overall Score: 90 – 100 = Excellent, 80 – 89 = Good, 70 – 79 = Acceptable, 50 – 69 = Weak, 00 – 49 = Lacking

Comments:

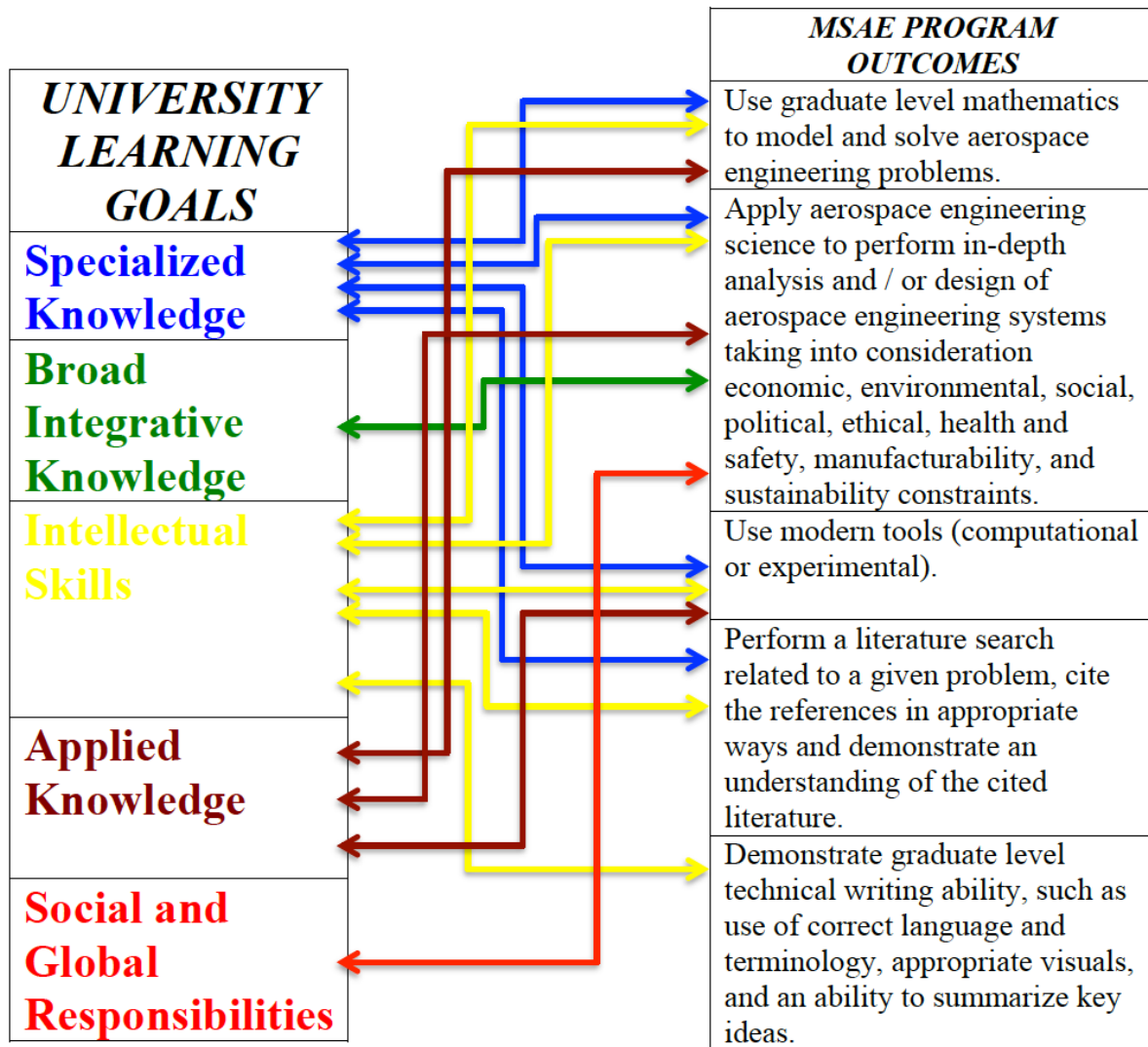
2. Map of PLOs to University Learning Goals (ULGs) No changes

The maps below are the product of several discussions in AE faculty meetings.

BSAE Program Outcomes / University Learning Goals Map



MSAE Program Outcomes / University Learning Goals Map



3. Alignment – Matrix of PLOs to Courses

<i>BSAE</i>	Student Outcomes								
	A	B	C	D	E	F	G	H	I
<i>Original ABET Outcomes</i>	(a), (e)	(b)	(c)	(d)	(g)	(f)	(h), (j)	(i)	(k)
Required Courses & Course Coordinators									
AE 112 – Prof. Hunter	++	○		○					○
AE 114 – Prof. Hunter	++	○		○	○				○
AE 138 – Prof. Hunter	++	○		○	○				○
AE 140 – Prof. Hunter	++			○	○			○	○
AE 157 – Dr. Turkoglu	++	○	○	○	○	○	○	○	○
AE 160 – Dr. Mourtos	++	○	○	○	○			○	+++
AE 162 – Dr. Mourtos	++	++		○	○		○	++	+++
AE 164 – Dr. Mourtos	++			○	○			○	○
AE 165 – Dr. Papadopoulos	++			○	○				○
AE 167 – Dr. Papadopoulos	++	○	○	○	○	○	○	○	○
AE 168 – Dr. Turkoglu	++	○	○	○	○			○	○
AE 169 – Dr. Papadopoulos	○			○	○			○	+++
AE 171 A, B – Dr. Mourtos AE 172 A, B – Dr. Papadopoulos	○	○	+++	+++	+++	+++	++	+++	+++
Extra Curriculum/Student Club Activities	○	○	○	○	○	○	○	○	○

+: Skill level 1 or 2 in Bloom's Taxonomy

++: Skill level 3 or 4 in Bloom's Taxonomy

+++ : Skill level 5 or 6 in Bloom's Taxonomy

○ Skill addressed but not assessed

MSAE Course / Outcome Mapping

<i>MSAE</i>	Student Outcomes				
	A	B	C	D	E
Required Courses					
AE 200	+++		★		
AE 242/AE 243/AE 245/AE 246/AE 247	★	★	★		
AE 250	★	★	★		
AE 262/AE 264/AE280	★	★	★	★	★
AE 267	★	★	★		
AE 269	★	★	★		★
AE 271		★	★	★	+++
AE 295A&B / AE299	★	+++	+++	+++	+++

++: Skill level 3 or 4 in Bloom's Taxonomy

+++ : Skill level 5 or 6 in Bloom's Taxonomy

★ Skill addressed but not assessed

4. Planning – Assessment Schedule

No changes

Timeline for BSAE Outcome Assessment

Outcomes									
	A	B	C	D	E	F	G	H	I
AY 11-12	X					X			
AY 12-13		X					X		
AY 13-14			X					X	
AY 14-15				X					X
AY 15-16	X				X				
AY 16-17		X				X			
AY 17-18			X				X		

Timeline for MSAE Outcome Assessment

Outcomes					
	A	B	C	D	E
AY 11-12	X				
AY 12-13		X			
AY 13-14			X		
AY 14-15				X	
AY 15-16	X				X
AY 16-17		X			
AY 17-18			X		

Plans for Implementing Course and Curriculum Improvements and Re-Assessment

Any recommendations made as a result of assessing a particular outcome/performance indicators, are implemented in the following AY and the outcome/performance indicator is re-assessed. If, following implementation of improvements, the performance indicator is met, no further action is taken until the next time the particular outcome is due for assessment.

5. Student Experience:

No changes

a. Communicating PLOs and ULGs to students:

PLOs and ULGs are:

- Posted on the BSAE and MSAE websites
- Included on course syllabi, linked to specific course learning objectives (CLOs).
- Communicated to students on the first day of class and throughout the semester in relationship to specific topics and course assignments.

b. Student input on PLOs and / or assessment process

Graduating seniors are surveyed with the following questions:

Question 1: What do you think are the most important skills for an AE to compete successfully for entry-level positions in industry?

Question 2: What do you think are the most important skills for an AE to succeed in graduate school?

Question 3: Do you feel that our AE program prepared you adequately in the skills you consider important? Write “yes” OR “no” next to each skill you identified in questions 1 and 2 above.

Questions 4: Which courses prepared you for these skills? Write next to each skill you identified in questions 1 and 2 the course(s) you think helped you develop these skills.

Responses from questions 1 and 2 are summarized and compared to the skills listed in the BSAE PLOs. If students identify any new skills not listed in the BSAE PLOs, AE faculty discuss and recommend whether to modify PLOs and include these newly identified skill(s).

Responses from questions 3 and 4 help determine whether – always according to students – the BSAE Program prepares them adequately in the skills they consider important and which courses are most effective in this regard.

Part B

6. Assessment Data and Results

Following the timelines shown above, we assessed in 2016:

BSAE Program

Outcome A: Ability to use mathematics, science, and engineering principles to identify, formulate and solve aerospace engineering problems.

Assessment Summary: Overall, **Outcome A is satisfied** in the BSAE Program

Outcome Element A-1: Ability to apply mathematics.

Performance Indicator A-1.3: Ability to apply linear algebra

AE 157 – Spring 2016 – Prof. Turkoglu

Assessment Summary: The performance target is **not met** for Performance Indicator A-1.3

Course Activities

- Describe transient response analysis in aircraft and satellites.
- Formulate basic control actions and frequency response of aerospace automatic control systems.
- Analyze stability and stability margins in aerospace vehicle motions.
- Outline the fundamentals of modern control theory as it is applied to aerospace vehicles
- Determine the natural frequencies and damping ratios of aerospace vehicle dynamics.
- Derive transfer functions and plot vehicle time and/or frequency response.
- Use frequency response design techniques to design closed-loop control systems: rate-damping, attitude control, altitude control.
- Design a satellite control law using classical/modern automatic control system design principles (such as PID, pole placement ... etc.).

Student Performance Results

In Exam 1, Question 4 student's linear equation handling, matrix analysis, matrix inversion and matrix manipulation/formation skills were tested.

	Students who scored 70% or higher
N=80; Passed = 78 (85%)	14 (21%)

Analysis

Only 21% of the students were able to demonstrate successful linear algebra application skills in the first exam. Application of linear algebra concepts as well as tools is a skill-set, which is picked up in Math129A or its equivalent at community colleges, and is a prerequisite to AE157. Unfortunately, students are prepared to tackle advanced control theory problems, which solely depend on linear algebra and algebraic spaces. During the semester, when students are advised to review their linear algebra skills, it is observed that they do not spend enough time outside the class to read, study and practice the material to master the application skills on linear algebra concepts. This trend is also observed in general reading assignments and tasks, as well. Students have been offered weekly problem solving workshops to help their problem solving skills. However, despite the fact that

participation in these workshops is strongly encouraged, students either do not have time to attend or show no interest in spending extra time to review their linear algebra skills under the guidance of a teaching assistant.

Solving more problems in class helps students in their understanding of linear algebra concepts, however, AE157 is a class in which Linear Algebra is a prerequisite and students are expected to come well equipped with analytical tools to tackle controls problems, rather than learning linear algebra skills along side with control concepts. Furthermore, hand-holding students leads students to memorize problem set-ups rather than focusing on understanding the core concepts underneath. This is observed, for example, when a concept is presented in a slightly different way/shape, requiring the same tools/skills, previously presented in class but nevertheless students are not able to apply these tools/skills.

Recommendations

- Perform diagnostic assessment in the beginning of the semester to test students' skills in linear algebra.
- Organize a meeting with the Math129A Coordinator in the Math Department to share our experience of ill-prepared students in linear algebra.
- Create reference material (e.g. notes, videos, etc.) as a review of fundamental linear algebra concepts to bring lagging students up to speed.

Implementation: Spring 2017

Outcome Element A-3: Ability to apply aerospace engineering principles.

Performance Indicator A-3.1: Ability to apply aerospace structures principles.

AE 114 – Spring 2016 – Prof. Boylan-Ashraf

Assessment Summary: The performance target **is met** for Performance Indicator A-3.1

Course Activities

- a. Determine tensile and compressive members of a spacecraft truss structures using both method of joints and method of sections.
- b. Calculate principal stresses and principal strains using transformation equations and Mohr's Circle of beam-column type wing and fuselage structures.
- c. Calculate aircraft material specimen displacements due to thermal affects.
- d. Analyze statically indeterminate axially-loaded aircraft assemblies and determine tensile and compressive elements.
- e. Calculate deformations in axially-loaded wing assemblies.
- f. Calculate stresses in thin-walled monocoque and semi-monocoque structures.
- g. Analyze statically indeterminate torsional shafts and determine angle of twist.
- h. Draw shear force and bending moment diagrams of fuselage beam structures.
- i. Examine combined (axial, torsional, and bending) fuselage loading and analyze principal stresses.
- j. Calculate bending deflection in wing and fuselage beam structures using integration and superposition methods.

Student Performance Results

	Students who scored 70% or higher
Exam 1	86%
Exam 2	47%

Exam 3	73%
Final Exam	92%

Analysis

This course provides an overview of aircraft structural external loads analysis using classical methods for statically indeterminate structures. This course is a continuation of AE 112 with an emphasis on deterministic stress analysis. The first exam was a review of AE 112 topics and the majority of the students performed satisfactorily. However, Exam 2 was a challenge for more than half the class due to exposure to unfamiliar topics covered for the very first time (strain gauge rosettes, principal strains, thermal strains, and axial deformation) –mental motivation toward critical thinking was the biggest hurdle.

To get over the fear of new topics since Exam 2, the course was broken up into numerous small goals. During each lecture students had to meet a certain “small” achievement goal, such as determining the correct angle in strain transformation equations – although a trivial goal for some students, yet a necessary piece of information in learning about rosettes. This is done through in-class problem solving or shot-gun exercises. Breaking up the course into small manageable pieces for the students seemed to take away the feeling of being overwhelmed of learning new concepts.

Recommendations: None

Implementation: N/A

Performance Indicator A-3.2: Ability to apply aerospace dynamics principles.

AE 140 – Spring 2016 – Prof. Hunter

Assessment Summary: The performance target **is met** for Performance Indicator A-3.2.

Course Activities

- Model particle motion with respect to the rotating Earth
- Identify and use Coriolis and centripetal acceleration components in solving problems of particle motion over the surface of the Earth
- Model a spinning spacecraft (body of revolution) in free motion using Euler angles: precession, nutation and spin
- Simulate the analytically derived equations in Matlab or MotionGenesis
- Compute mass properties (moments & products of inertia) and use these properties to predict rotational stability
- Derive the rotational equations of motion of a spinning rigid body in two cases: a spinning spacecraft (no gravity – angular momentum conserved); a gyroscope or top with the forcing function of gravity torque: (angular momentum not conserved).
- Use the equations of rotational motion to model a spin-stabilized missile
- Model a spinning body in forced motion (i.e., with applied moments due to gravity, drag, differential lift, etc.)
- Model the motion of a helicopter rotor blade in gyroscopic precession
- With Lagrange’s equation, write the equations of motion of a particle or rigid body

Student Performance Results

	Students who scored 70% or higher
Exam 1	64%
Exam 2	69%
Final Exam	86%

Analysis

AE140 is the second class in a two-course dynamics sequence. In AE140, students solidify their knowledge of dynamics. They learn to look at six degree of freedom (DOF) dynamic systems as three DOF particle motion (of vehicle center of mass) and three DOF rotational motion (about the center of mass). Within this framework, we analyze many aerospace systems: spacecraft, aircraft, missiles, helicopters, as both particles and rigid bodies.

The low exam scores in the beginning of the semester appear to be the result of the inability to visualize motion in three dimensions. In addition to being a challenging class mathematically, a goal of the class is to merge the students' intuition about 6-DOF motion with the results of their analyses. This takes time, but by the end of the semester, most of the students are able to understand the motion both spatially and analytically.

Although group project grades are not included in the table above, applying their knowledge by doing a project has key learning value for the students. As a result of the project, their knowledge is much more solid by the final exam.

Recommendation: Develop rigid body dynamics visualization tools as project topics.

Implementation: Spring 2017

Performance Indicator A-3.4: Ability to apply flight mechanics principles

AE 165 – Spring 2016 – Prof. Hunter

Assessment Summary: The performance target **is met** for Performance Indicator A-3.4.

Course Activities

- Compute the maximum rate of climb, maximum velocity, service and absolute ceilings for various aircraft
- Calculate $(L/D)_{\max}$, range and endurance for several aircraft as these parameters vary with altitude
- Find minimum turn radius and maximum turn rate for a steady, level turn
- Determine of aircraft longitudinal static stability coefficients from geometry and aerodynamic data
- Compute eccentricity, semi-major axis length, angular momentum for a planar Keplerian orbit
- Find spacecraft particle velocity as a function of orbit radius and orbit parameters
- Calculate circular orbit velocity and planetary escape velocity

Student Performance Results

	Students who scored 70% or higher
Exam 1	59%
Exam 2	92%
Final Exam	94%

Analysis

Flight Dynamics is an introductory class in aircraft performance, aircraft stability and orbital mechanics. The particular challenge of this class is its combination of three distinct topics in flight mechanics. The two aircraft topics (performance and stability & control) will be connected explicitly in subsequent classes, while orbital mechanics is an application of particle dynamics for Earth-orbiting spacecraft. The low scores on the first exam indicate that the students were somewhat slow to embrace the new applications that they encountered in Flight Mechanics. However, by working many examples in class and often letting the students work problems in a group and present their

solutions to the class, students did master the material, as indicated by their performance on Exam 2 and the Final Exam.

Another essential element of student success is integrating the AE165 and AE162 (Aerodynamics II) course projects. Since most students take AE162 and AE165 concurrently, the projects are assigned jointly, using the same aircraft. The students calculate aerodynamic forces on their aircraft in AE162, and then use those forces to predict vehicle performance and open-loop stability in AE165.

Recommendation: None

Implementation: N/A

Performance Indicator A-3.5: Ability to apply aerospace propulsion principles

AE 167 – Spring 2016 – Prof. Carlozzi

Assessment Summary: The performance target **is met** for Performance Indicator A-3.5.

Course Activities

- Perform thermodynamic analysis of ramjet, turbojet, and turbofan engines
- Analyze the performance of subsonic and supersonic inlets
- Analyze the performance of combustors, afterburners, and exhaust nozzles
- Analyze the performance of axial flow compressors
- Carry out flight performance calculations for rockets
- Analyze the performance of solid and liquid rockets

Student Performance Results

Students who scored 70% or higher						
Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6	Quiz 7
69 (89%)	55 (79.3%)	66 (89.4%)	61 (84.9%)	59 (81.7%)	38 (64.4%)	63 (85.8%)

Analysis

Based on my personal observations and one-on-one conversations with students, I would say the most significant contributor to poor quiz performance would be the lack of time spend outside of class (reading the textbook, looking at example problems, solving problems in addition to those assigned for homework.) One of my top performing students said he committed at least 5 hours per week, outside of class, to AE 167 related activities. Another contributing factor to poor quiz and homework performance is a lack of preparation before each class. At the beginning of class, I would occasionally ask if anyone had read or looked at the material we would be discussing that day. At best, 5-10% of the students raised their hands. Students who read ahead get the most out of class lectures, since they are able to contribute to in-class discussions and ask questions related to topics not clear to them. Many students did not take advantage of my office hours. Throughout the semester, only about 20% of my office hour time was spent helping and talking to students. I made a conscious effort to continuously invite students to see me during my office time to clear up any questions, concerns, or lack of understanding of course material.

On the other hand, I was pleased to see the vast majority (at least 80%) of students taking advantage of the in-class time spent for solving workout problems. Many would come to me for help, or to check their final answers. Group work and student collaboration was impressive (which is expected for an upper division course comprised primarily of graduating seniors.)

Biweekly quizzes are a more effective way to solidify and assess student learning and comprehension as compared to one mid-term plus a final exam. Students also favored this approach. This proved especially true when more challenging topics (axial flow compressors, velocity triangles, etc...) were discussed. Quiz #5 was on axial flow compressors, and I was pleased to see almost 82% of the class scoring a 70% or better.

Recommendation: None.

Implementation: N/A.

Outcome Element A-4:

Ability to identify, formulate and solve aerospace engineering problems

AE162 – Spring 2016 – Prof. Nikos J. Mourtos

Assessment Summary: The performance target is **not met** for Outcome Element A-4.

Outcome Performance Indicators

A4.1: Engage in the solution of problems (spend adequate time on task, ask questions, etc.).

A4.2: Define (open-ended) problems in appropriate engineering terms.

A4.3: Explore problems (i.e., examine various issues, make appropriate assumptions, etc.).

A4.4: Develop a plan for the solution (i.e., select appropriate theories, principles, approaches).

A4.5: Implement their solution plan and check the accuracy of their calculations.

A4.6: Evaluate their results and reflect on their strengths and weaknesses in the process.

Assessment Summary

The performance target is...

Met for Performance Indicator A4.1.

Met for Performance Indicator A4.2.

Not met for Performance Indicator A4.3.

Met for Performance Indicator A4.4.

Met for Performance Criterion A4.5

Met for Performance Criterion A4.6.

Course Activities

Students propose a project that integrates theory and applications from AE162, AE165 and possibly other courses (e.g. AE114, AE157). A final report is due at the end of the semester. Students:

1. Select an airplane with a high AR wing.

2. Potential Flow Simulation

Use the Potential Flow Theory Program to simulate the flow around the fuselage of their selected airplane. They plot the streamlines around the fuselage and write the stream function and the velocity potential function.

3. Airfoil Study

a. Define criteria for selecting an airfoil for their airplane.

b. Based on these criteria, they find at least 10 potential airfoils and compare them using published data and software such as XFLR5.

c. Based on their criteria they select the best airfoil for their airplane wing.

d. Use thin airfoil theory to estimate the aerodynamic characteristics of their selected airfoil and compare with actual data.

4. Wing Study

a. Perform a parametric study to determine the best combination of sweep angle,

- thickness ratio and taper ratio. They use wing weight as their figure-of-merit. They use the WingDesign software of Desktop Aeronautics or any other piece of software they see fit.
- b. Calculate the lift and drag characteristics of their wing using the monoplane equation.
 - c. Estimate the maximum lift coefficient of their wing, using the WingDesign software of Desktop Aeronautics.

5. Drag Polars

Calculate the low and high-speed (if appropriate) drag of their entire vehicle. Derive and plot the drag polars for the cruise, takeoff, and landing configurations.

AE165 Project Requirements

6. Estimate the takeoff and the landing performance of their airplane; compare your results with actual performance data.
7. Estimate the climb performance of their airplane; compare their results with actual performance data.
8. Estimate the cruise performance of their airplane; compare their results with actual performance data.
9. Estimate the range/endurance of their airplane; compare their results with actual performance data.
10. Estimate the glide performance of their airplane; compare their results with actual performance data.
11. From planform geometry and aerodynamic data, calculate the stability derivatives

C_{M_α} and $C_{M_{\delta_e}}$ of their aircraft.

Student Performance Results (AE162 only)

	Students who scored 70% or higher							
	Potential Flow Modeling	Airfoil Comparison	Thin Airfoil Theory Analysis	Wing Parametric Study	Wing Weight	Wing Aerodynamic Characteristics	Airplane Drag Polars	Total Project Score
N=78; passed=72 (92%)	63 (88%)	60 (83%)	64 (89%)	50 (69%)	51 (71%)	67 (93%)	24 (33%)	63 (88%)

Analysis

A4.1 – As student performance results show, the majority of the students (88%) did indeed engage with their open-ended project (spent adequate time on task, asked questions throughout the semester, etc.) and produced a high quality report.

A4.2 – In their airfoil comparison, 65% defined selection criteria appropriate for their airplane; the rest used a generic list of criteria presented in class without regard to the specific requirements of their particular airplane. On a positive note, 83% of the students used XFLR5 effectively in comparing the various airfoils in their database.

A4.3 – Only 69% of the students were able to frame their wing parametric study appropriately, making proper assumptions and using the wing structural weight as a figure of merit in selecting the best possible wing design for their airplane.

A4.4 – Students were able to select appropriate theories, principles, and approaches in carrying out the various parts of their project (e.g. potential flow theory, thin airfoil theory, etc.) except for the calculation of their drag polars. This was surprising, as this topic was discussed in AE160 (a prerequisite for AE162), and was also reviewed in AE162 on two separate occasions during class. While 11% (8) of the students did exceptional work on their drag polars with a level of detail above and beyond the call of this assignment and another 22% (16) performed a very good drag polar

analysis, 67% of the students were lost and did not seem to know what drag polars were or how to estimate them.

A4.5: Overall, students did implement effective plans for the potential flow simulation of their airplane fuselage, the comparison of the various airfoils they selected, and the calculation of the aerodynamic characteristics of their wing. Furthermore their results were fairly accurate.

A4.6: Students evaluated their results and reflected on their strengths and weaknesses, while carrying out the various parts of this project.

Recommendations

1. Case studies will be presented and discussed in class to demonstrate the different requirements of airfoils designed for different airplanes.
2. Several parametric studies will be presented in class involving wing parameters to illustrate how such studies can be used to optimize wing design.
3. A step-by-step process will be added to the class notes to guide students in their estimation of drag polars for an airplane in cruise, takeoff, and landing configurations, allowing also for compressibility drag if the plane operates at high speeds.

Implementation: Spring 2017

OUTCOME B

Ability to design and conduct water tunnel and wind tunnel experiments, as well as to analyze and interpret data from such experiments.

AE160 – Fall 2016 – Prof. Nikos J. Mourtos

Assessment Summary: The performance target **is met** for Outcome B.

Course Design to Address Outcome B

The laboratory experience in AE160 and AE162 has been re-designed to include:

- a. Instruction on how to design experiments.
- b. Modification of the original experiments from ‘cook-book’ to open-ended: students design their own experiments, given a general goal.
- c. Introduction of a Design-of-Experiment (DoE) process (Du, Furman, and Mourtos, 2005), which students are required to use:

Step 1 – Define specific and measurable objectives for the experiment.

Step 2 – Research the relevant theory and previously published data from similar experiments.

Perform computer simulations if appropriate software is available. The purpose of this step is to prepare students on what to expect from the experiment.

Step 3 – Select the dependent and independent variable(s) to be measured.

Step 4 – Select appropriate methods for measuring / calculating each variable.

Step 5 – Select the proper range for the independent variable(s).

Step 6 – Determine an appropriate number of data points needed for each type of measurement.

- d. Development of rubrics (see below) to evaluate student performance in each step of this process (Anagnos, Komives, Mourtos, and McMullin, 2007).
- e. In both courses, students write extensive lab reports for each lab experiment, in which they present their design, results, and discussion (interpretation) of their results. Their lab reports are graded using the rubric below.

Course Activities (AE 160)

- Design and perform a water tunnel experiment to study the effects of shape and angle of attack on the flow pattern around an airfoil, a forebody, and a delta-wing aircraft model and report the results. As part of the study students distinguish basic flow features, such as laminar or turbulent flow, attached or separated flow, etc.
- Design and perform a wind tunnel experiment to study the effects of shape and Reynolds number on the aerodynamic drag of 2-D and 3-D bodies and analyze the results.
- Design and perform a wind tunnel experiment to study the drag of an airfoil from wake measurements and analyze the results.
- Design and perform a wind tunnel experiment to study boundary layer characteristics on an aerodynamic surface and analyze the results from such experiments.

Course Activities (AE 162)

- Design and perform a wind tunnel experiment to study the effects of Reynolds number on the pressure distribution of a circular cylinder and compare with potential flow theory results (new experiment, implemented in Spring 2011).
- Design and perform a wind tunnel experiment to study the effect of angle-of-attack and Reynolds number on the pressure distribution of an airfoil and compare the results with published and computational data.
- Design and perform a wind tunnel experiment to study the effect of angle-of-attack and Reynolds number on the lift and drag characteristics of an airfoil and compare the results with theoretical, published and computational data.

Design and perform a wind tunnel experiment to study the effect of high-lift devices on the lift and drag characteristics of an airfoil and compare the results with published and computational data (new experiment, implemented in Spring 2011).

Assessment Tools

- One lab report (water tunnel experiment) in AE160.
- One lab report (wind tunnel experiment) in AE162.

Design-of-Experiments Rubric

1. Given the general goal of an experiment, define *specific and measurable objectives* for this experiment.

NOT PASS	0	No objectives defined for this experiment.
	1	Objectives identified but <ul style="list-style-type: none"> Not relevant to experiment OR Contain technical or conceptual errors OR Not measurable
PASS	2	Objectives are conceptually correct and use correct technical terminology but may be incomplete in scope or have grammatical errors.
	3	Objectives are complete, conceptually correct, concise, and use correct technical terminology but may have grammatical errors.
	4	Objectives are complete, conceptually correct, concise, specific and clear, and use correct technical terminology and grammar

2. Research and summarize the *relevant theory* for this experiment.

NOT PASS	0	No theory section is included in the report.
	1	A theory section is included but it is not relevant to the experiment.
PASS	2	Theory section includes some of the relevant equations and some discussion relevant to the experiment. Theory is used to predict some of the experimental results.

	3	Theory section is well written, with equations and some discussion relevant to the experiment. Theory is used to predict experimental results.
	4	Theory section is well written, with equations and discussion relevant to the experiment. Theory is used to predict experimental results.

3. Research and summarize ***previously published data*** from similar experiments.

NOT PASS	0	Previously published data are not included in the report.
	1	Published experimental data, and computer simulations included but not relevant to the experiment.
PASS	2	Theory section includes some of the relevant equations and some discussion relevant to the experiment. Published experimental data or computer simulations relevant to the experiment are included but not used to predict experimental results.
	3	Theory section is well written, with equations and some discussion relevant to the experiment. Published experimental data and / or computer simulations relevant to the experiment are included but not used to predict experimental results.
	4	Theory section is well written, with equations and discussion relevant to the experiment. Published experimental data are included as well as computer simulations relevant to the experiment. Theory, published data, and simulations are used to predict experimental results.

4. Perform appropriate ***computer simulations*** relevant to this experiment.

NOT PASS	0	Computer simulations are not included in the report.
	1	Computer simulations are included but are not relevant to the experiment.
PASS	2	Computer simulations relevant to the experiment are included but not used to predict experimental results.
	3	Theory section is well written, with equations and some discussion relevant to the experiment. Published experimental data and / or computer simulations relevant to the experiment are included but not used to predict experimental results.
	4	Theory section is well written, with equations and discussion relevant to the experiment. Published experimental data are included as well as computer simulations relevant to the experiment. Theory, published data, and simulations are used to predict experimental results.

5. Select ***dependent and independent variables*** to be measured (or controlled)

NOT PASS	0	Did not identify variables.
	1	Identified variables but did not distinguish dependent and independent.
PASS	2	Identified dependent and independent variables and relationship between them.
	3	Identified dependent and independent variables and relationship between them.
	4	Identified dependent and independent variables and relationship between them.

6. Select appropriate ***methods for measuring / controlling each variable***

NOT PASS	0	Did not identified methods for measuring/controlling variables
	1	Identified inappropriate method(s)
PASS	2	Method(s) listed with no description or incomplete description OR Complete description of method(s) presented, but list is not comprehensive
	3	Comprehensive list of possible methods of measurement and instrumentation with complete descriptions but no discussion of limitations and dynamic range
	4	Comprehensive list of possible methods of measurement and testing instrumentation and equipment based on available resources with complete descriptions including a discussion of limitations and dynamic range

7. Select appropriate ***equipment and instrumentation***

NOT PASS	0	Did not identify instrumentation and equipment for measuring/controlling variables.
	1	Identified inappropriate instrumentation and equipment.
PASS	2	Selected appropriate instrumentation and equipment with no justification OR

		incomplete list of instrumentation.
	3	Selected appropriate instrumentation and equipment with incomplete justification.
	4	Selected appropriate instrumentation and equipment with complete justification (e.g. based on accuracy, sensitivity, reliability, and available resources).

8. Select a proper *range for the independent variables*

NOT PASS	0	Ranges not identified
	1	Ranges grossly unreasonable*** OR Ranges provided with no justification
PASS	2	Range is reasonable* but not adequately justified OR Range is unreasonable but based on correct theory with mathematical errors
	3	Reasonable* range for all independent variables that are justified based on appropriate but possibly incomplete use of literature, correct theoretical calculations, and equipment/instrumentation limitations.
	4	Optimal** range for all independent variables that are justified based on appropriate use of literature, theoretical calculations, and equipment/instrumentation limitations.

* reasonable – pushing the limits of equipment, instrumentation or specimens, or captures some aspects of system behavior but is inadequate for complete analysis

** optimal – range will capture full response of system, is within limitations of equipment, instrumentation, and specimens, and will provide sufficient data for a statistically valid and complete analysis

*** unreasonable – theoretically impossible, or significantly outside the limits of the equipment, instrumentation, or specimens

9. Determine an appropriate number of data points needed for each type of measurement.

NOT PASS	0	Number of data points not identified
	1	Number of points grossly unreasonable OR Number of points provided with no justification
PASS	2	Number of points is sufficient to capture mathematical properties in an ideal world, but insufficient in the presence of experimental error or other confounding factors
	3	Reasonable* number of points for measurements, justified based on some but not all of the following: theory, equipment limitations, and potential error
	4	Reasonable* number of points for all measurements, justified based on consideration of theory, equipment limitations, and potential error

* reasonable – a sufficient number of points to capture the mathematical properties of the relationship (e.g. linear versus logarithmic).and account for possible measurement error.

*** unreasonable – insufficient number of points to capture the mathematical properties of the relationship

Lab Report Grading Rubric

	Total Score	106
1. Abstract		10
2. Experimental Design		36
• (1) Define specific and measurable objectives for the experiment		4
• (2) Research / summarize relevant theory		4
• (3) Research / summarize previous data		4
• (4) Computer simulations (if available)		4
• (5) Select dependent and independent variables		4
• (6) Select appropriate methods to measure these variables		4
• (7) Select appropriate equipment and instrumentation to measure these variables		4
• (8) Select proper range for independent variables		4
• (9) Determine appropriate number of data points for each type of measurement.		4
3. Experimental results		20

4. Discussion		20
<ul style="list-style-type: none"> • Interpretation of results • Explanation of any discrepancies with theory and / or published data and / or computer simulations 		
5. References		10
6. Appendices		10
<ul style="list-style-type: none"> • Raw data • Data Analysis - Calculations • Published data • Other 		

Outcome Element B-1: Ability to design water tunnel and wind tunnel experiments

Assessment Summary: The performance target **is met** for Outcome Element B-1.

Performance Indicators for Outcome Element B-1

B-1.1: Given the general goal of an experiment, define specific and measurable objectives for this experiment.

B-1.2: Research and summarize the relevant theory for this experiment.

B-1.3: Research and summarize previously published data from similar experiments.

B-1.4: Perform appropriate computer simulations relevant to this experiment.

B-1.5: Select dependent and independent variables to be measured (or controlled).

B-1.6: Select appropriate methods for measuring / controlling each variable.

B-1.7: Select appropriate equipment and instrumentation.

B-1.8: Select a proper range for the independent variables.

B-1.9: Determine an appropriate number of data points needed for each type of measurement.

Student Performance Results

Enrolled = 95	Passed (C- or better) = 92 (97%)								
	Students who scored 2, 3 or 4 on the Design-of-Experiments Rubric								
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9
AE 160 – Fall 2016	75%	50%	92%	N/A	83%	96%	96%	100%	92%

Analysis

The performance target was met for all the steps in the design-of-experiment process except for Step 2, which calls for a summary of the relevant theory of the particular experiment. The reason for this is that the experiment assessed involved flow visualization in the water tunnel and the theory pertaining to the flow around some of the models is not explicitly discussed in AE160 (e.g. separated flows around airplanes and conical bodies at high angles of attack). Although references were provided, some students were not able to identify key points and summarize them in their discussion of relevant theory.

Recommendation

A summary of the relevant theory for separated flows around delta-winged aircraft and bodies of revolution at high angles of attack will be provided to students during lecture as well as in notes, along with references for further study.

Implementation: Fall 2017

Outcome Element B-2: Ability to conduct water tunnel and wind tunnel experiments

Assessment Summary: The performance target **is met** for Outcome Element B-2.

Performance Indicator for Outcome Element B-2

Given an experimental setup, become familiar with the equipment, calibrate the instruments to be used, and follow the proper procedure to collect the data.

Laboratory Activities

- Students prepare for their experiments beforehand. The equipment manuals as well as questions pertaining to each experiment are posted on the courses' website.
- Students turn in written answers to these questions and must score a minimum of 70% before they are allowed to perform their experiment.
- Students turn in their design-of-experiment for approval before they are allowed to use the equipment in the Aerodynamics Lab.
- For safety reasons students conduct their experiments under the supervision of a lab assistant, who is usually an MSAE student familiar with the equipment. He/she (a) demonstrates all the equipment and instrumentation in the Aerodynamics Lab, (b) ensures that students are indeed familiar with the equipment before allowed to operate the wind and the water tunnel, and (c) supervises all experiments to ensure students follow proper procedures.

Assessment Process

Following each experiment, the Lab Assistant certifies that each student is capable of conducting the experiment.

Recommendation: None.

Implementation: N/A

Outcome Element B-3: Ability to analyze data from water tunnel and wind tunnel experiments

Performance Indicator for Outcome Element B-3

Given a set of experimental data, carry out the necessary calculations and tabulate / plot the results using appropriate choice of variables and software.

Student Performance Results

Enrolled = 95	Passed (with a "C-" or better) = 92 (97%)
	Students who scored 70% or higher in the results section of their lab report
AE 160 – Fall 2016	87 (95%)

Analysis

The results section of the flow visualization experiment involved photographs and sketches of the various types of flows observed in the water tunnel. The photographs and sketches presented by most students captured the essential flow features observed in the water tunnel experiments and compared well with published data.

Recommendation: None

Implementation: N/A

Outcome Element B-4: Ability to interpret data from water tunnel and wind tunnel experiments

Performance Indicators for Outcome Element B-4

B-4.1: Given a set of results in tabular or graphical form, make observations and draw conclusions regarding the variation of the parameters involved.

B-4.2: Given a set of results in tabular or graphical form, compare with theoretical predictions and/or other published data and explain any discrepancies.

Student Performance Results

Enrolled = 92	Passed (with a "C-" or better) = 92 (97%)
	Students who scored 70% or higher in the discussion section of their lab report
AE 160 – Fall 2017	79 (86%)

Analysis

Some students had difficulty interpreting the flow visualization patterns of the three-dimensional bodies tested in the wind tunnel (conical body and delta-wing aircraft). This difficulty was the result of: (a) students' unfamiliarity with these types of flows, (b) the fact that these flows are discussed in more detail later on in the course, and (c) the fact that students did not take the time to read the references provided, including the course textbook. As a result, some students performed poorly in the design of their experiment, as discussed above in relationship with Outcome Element B-1 and in particular with Outcome Performance Indicator B-1.2, but also in their interpretation of the flow patterns observed.

Recommendation

Some discussion will be provided in class to guide students on how to interpret the flow patterns observed in their water tunnel experiment.

Implementation: Fall 2017

Outcome E: Ability to communicate effectively through technical reports, memos, and oral presentations as well as in small group settings.

AE171B – Spring 2016 – Prof. Gonzalo E. Mendoza

AE172B – Spring 2016 – Prof. Marcus S. Murbach

Assessment Summary: Overall, **Outcome E is satisfied** in the BSAE Program

Outcome Element E-1: Ability to communicate in writing

Outcome Performance Indicators

E-1.1: Produce well-organized reports, following guidelines.

E-1.2: Use clear, correct language and terminology while describing experiments, projects or solutions to engineering problems.

E-1.3: Describe accurately in a few paragraphs a project / experiment performed, the procedure used, and the most important results (abstracts, summaries).

E-1.4: Use appropriate graphs and tables following published engineering standards to present results.

Assessment Summary

The performance target **is met** for Performance Indicators E-1.1, E-1.2, E-1.3, and E-1.4.

Course Activities (AE171B)

- Prepare a draft technical report highlighting all relevant aspects of design covered in AE171A, expanded to incorporate preliminary systems testing and performance assessments resulting from an initial test article demonstration. Guidelines based on AIAA student competition requirements are enforced.
- Write a final design report, including revised content from the draft report, as well as a technical section related to test plans, test results, and recommendations for future work. Guidelines based on AIAA student competition requirements are enforced.
- Write an individual paper addressing a topic related to aerospace ethics, safety, and/or liability. Paper must include a minimum of three valid references appropriate for academic use.
- Document test plans, flight test cards, and incident reports as outlined by the class aircraft design and operations manual.

Course Activities (AE172B)

- Prepare a draft technical report highlighting all relevant aspects of design covered in AE172A, expanded to incorporate preliminary systems testing and performance assessments resulting from an initial test article demonstration. Guidelines based on AIAA student competition requirements are enforced.
- Write a final design report, including revised content from the draft report, as well as a technical section related to test plans, test results, and recommendations for future work.
- Write an individual paper addressing a topic related to aerospace ethics, safety, and/or liability. Paper must include a minimum of three valid references appropriate for academic use.
- Document test plans, and developmental notes throughout the project evolution process.

Assessment Tools: Technical reports, test article documentation, and individual papers.

Student Performance Results

	Students who scored 70% or higher <i>NB: Only students who passed each course are included in the statistics below</i>					
	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6
AE171B – Spring 2016	22 (81%)	27 (100%)	25 (93%)*	N/A	N/A	N/A
AE172B – Spring 2016	N/A	N/A	N/A	34 (100%)	34 (100%)	34 (100%)

**Individual ethics assignment.*

AE171B – 20% of the total grade of the course is based on development of two formal technical papers outlining all aspects of the student projects, with emphasis on test plans and results. An additional 4% of the grade was assigned to an individual paper addressing ethics, safety, and/or liability in Aerospace Engineering. Finally, 10% of the test article delivery grade was assigned to associated paperwork including flight test cards, plans, and incident reports.

Each of the reports for both courses must follow a clear instructor provided rubric and conform to technical guidelines as provided by the AIAA and SAE student competition committees.

Early design report drafts were inconsistent with the standards set for the class. Students were given the opportunity to submit updated drafts throughout the semester, which generally resulted in better results. Overall, student performance was satisfactory in area E-1.1, with good adherence to report guidelines being the norm. Performance in E-1.2 was adequate, with inconsistency in technical

language use being the primary area for corrective feedback. Area E-1.3 was met satisfactorily with the caveat that students struggle with the idea of presenting a full summary, including results and conclusions, as part of the introductory sections of a document. Performance in area E-1.4 was mixed, with students having difficulty manipulating graphs to ensure appropriate presentation with complete and readable labels, legends, and titles. In repeated occasions the students showed difficulty in changing chart types, axis limits, and other default settings on their data manipulation programs to ensure proper depiction of said data.

Observations noted during evaluation of reports indicate that performance is hampered by:

- Fundamental difficulty using formal technical language: It is noted that, with few exceptions, students perform adequately in individual writing assignments not requiring rigorous technical language and formatting. Students, however, struggle to retain a consistent technical voice throughout their formal design reports.
- Inadequate task planning and time-on-task: Students typically turned in papers in the early hours of the morning (1-3 am) on the day following the deadline. All but the top scoring Teams acknowledged they had done little to prepare for the reports until the day before they were due. Given the amount of complex calculations, background research, and general analysis required for each report, students' typically allowed the important task of checking language, grammar, formatting, quality of graphs, etc, to take a back seat. Students' performance improved markedly when given additional time to work on their documents after resolving issues with calculations, experiments, and analysis. Few students presented adequate paperwork (flight cards, incident reports, build records) for their test articles following long nights of construction activity. Not surprisingly, students working ahead of deadlines had markedly superior reports and documentation

Recommendation

Implement an enhanced review of documentation standards. Minimum requirements are spelled out in the provided guidelines; however, additional discussion, with pertinent examples, should improve initial report outcomes. Review should focus on use of technical language and introductory to charting data in Microsoft Excel and Matlab; both commonly used by students.

Implementation: AY 2016 – 2017

AE172B – 60% of the total grade of the course is based on development of the formal technical reports/presentations outlining all aspects of the student projects and related management/execution. 20% of the grade is based on test plans, rapid-prototyping, supporting analysis. Finally, 20% of the grade is the summary final exam – as an extension of topics introduced in the previous semester.

Early in the first semester (and reinforced in the second), the NASA Project Engineering Handbook, as well as NPR 7120.5 processes were introduced. Such topics as general content, entrance/exit criteria, management of sponsor expectations was covered. The origins of complex project management was introduced – as well as key examples from the origins of architectures/topologies that led to the Apollo and Shuttle Programs. Also, small project management techniques – using the Wright brothers as an example, were also developed (counterpoint- why did S. Langley fail to produce the first aircraft – when he had all of the necessary resources).

Also – over the course of both semesters, the students were introduced to ‘real-time’ projects, which included the SOAREX-9 flight (March 7, 2016), the execution/delivery of the TechEdSat-5 nano-satellite, as well as the flight test of the Super-Strypi (watched on live feed in class). These real-time project examples, which include some of the SJSU students, were used to reinforce course concepts. The use of the weekly QUAD charts and ensuing discussion helped to keep the teams focused and is highly recommended. Lastly, various movies and videos describing the evolution of the Apollo and Shuttle programs (video from experts involved in their development) was very well received by students.

Recommendation

All students will produce a 3D printed part related to the overall system/project through rapid prototyping.

Implementation: AY 2016 - 2017

Outcome Element E-2: Ability to communicate orally

Outcome Performance Indicators

E-2.1: Give well-organized presentations, following guidelines.

E-2.2: Make effective use of visuals.

E-2.3: Present the most important information about a project / experiment, while staying within allotted time.

E-2.4: In small group settings, listen carefully, ask clarifying questions when others speak, and respect the opinion of others when disagreeing.

Assessment Summary

The performance target **is met** for Performance Indicators E-2.1, E-2.2, E-2.3, and E-2.4.

Course Activities (AE171B)

- a. Prepare a pre-competition/demonstration design review outlining modifications, future test plans, and initial test results of the student projects. Objective is to receive authorization to move forward to the final testing and development phase.
- b. Prepare a final design review outlining the entire project development journey, including final performance results and recommendations for future projects.
- c. Prepare and take part on an individual discussion regarding an aerospace engineering ethics, safety, and/or liability topic of the student’s choosing.

Course Activities (AE172B)

- a. Prepare for the Delta-CDR based on progress and comments from the end of the first semester. This is followed with the weekly QUAD chart style of reporting.
- b. Present the final project hardware/software as a functional system (as appropriate).
- c. Prepare and take part on an individual discussion regarding an Aerospace Engineering ethics and societal implications.
- d. Present a space system sub-topic in technical detail from the NASA-Ames State-of-the-Art paper, as well as the SMAD (Space Mission Analysis and Design) by J. Wertz, et al.

Assessment Tools

Formal design reviews with Q&A, debates and class discussions on assigned topics.

Student Performance Results

	Students who scored 70% or higher <i>NB: Only students who passed each course are included in the statistics below</i>		
	Formal Design Review 1	Formal Design Review 2	Graded Discussion
AE171B – Spring 2016	27 (100%)	27 (100%)	27 (100%)
AE172B – Spring 2016	34 (100%)	34 (100%)	34 (100%)

AE171B – 10% of the grade of the course is based on two formal design reviews. The first review is scheduled ahead of test article testing and competition activities, while the second review summarizes the entire journey at the end of the course. An additional 2% of the course grade is assigned to individual discussion and technical debate on student selected ethics, safety, and/or liability topics in Aerospace Engineering.

Students generally did well in oral presentations and debates, particularly in regards to areas E-2.1 and E-2.4. Students stayed fairly close to the provided guidelines with minimal prompting. During debates, while addressing controversial topics, students remained appropriately composed while vigorously presenting their points. Minimal moderation was required during these discussions. Area E-2.2 performance was adequate, with slides and visuals generally adding value to the presentations. Typical formatting problems, such as use of excessive text, inadequate text font size, and distracting colors and backgrounds, were evident in a number of presentations, but decreased significantly which each subsequent presentation. Area E-2.3 presented the most significant challenge, with students at times struggling to identify appropriate material to cut or reduce in order to stay within the time allotment.

Recommendation

Current mechanisms for differentiating individual contributions to team presentations do not sufficiently capture differences in student performance. It is expected that increasing the proportion of the presentation grade allotted to individual performance will drive additional preparation.

Implementation: AY 2016 – 2017

AE172B – 60% of the grade of the course is based on the associated reviews, as in the first semester. All students participate in the oral presentations. Weekly, different team members present the QUAD chart and any backup material. Also, there is lively discussion with the set of reflection papers.

Students generally did well in oral presentations and debates. Again, the weekly QUAD chart and reporting system, with alternating team members seemed to work well. In most cases the visual presentations were well done, and captured the current state of the project technical progress. In addition, it was requested that the team presented a ‘risk’ chart, so that the risk reduction posture was well noted. Many times, the emphasis was placed on concise technical content and that such a lucid presentation would be as desirable to a technical review team or venture capitalist. Rotating the oral team presentation went very well. Particularly for the shy students, an atmosphere of friendship was created so that they would have a chance to perform some public speaking. The weekly QUAD chart style of reporting permitted rapid feedback, so that when the critical design review material was presented it was crisper and more concise.

Recommendation: None.

Implementation: N/A

MSAE Program

Outcome A – Ability to use graduate level mathematics to model and solve aerospace engineering problems.

AE200 – Fall 2016 – Prof. Kamran Turkoglu

Assessment Summary: Overall, **Outcome A is satisfied** in the MSAE Program.

Outcome Performance Indicator

Derive, model and solve mathematical models of aerospace engineering problems.

Course Activities

Students...

- a. Outline analysis skills in real and functional analysis, complex analysis methods.
- b. Investigate the response of aerospace systems to inputs and initial conditions from the control theory perspective.
- c. Analyze aerospace systems obtained as interconnections (e.g., feedback) of two or more other systems.
- d. Derive (control) systems (and properties) that ensure desirable properties (e.g., controllability, observability, stability, performance) of the interconnection with a given dynamic system.
- e. Analyze least squares solutions to linear problems.
- f. Explain singular values and matrix perturbations.
- g. Derive solutions to state space models.
- h. Derive input output relationships and transfer functions between systems.
- i. Analyze input output stability of control systems.
- j. Use Bode's sensitivity integral to outline robust stability.
- k. Formulate reachability and observability.
- l. Use minimal and balanced realizations.
- m. Outline H2 and H-inf. optimization in control systems.

Assessment Tool: Final course project report.

Student Performance Results

	Students who scored 70% or higher on their final project report
AE 200 - Fall 16	22/22
N = 24; Passed = 22 (92%)	(100%)

Analysis

Students successfully demonstrated their ability to model and solve aerospace engineering problems, as well as their ability to communicate their results effectively.

Recommendations: None

Outcome B – Ability to apply aerospace engineering science (aerodynamics, propulsion, flight mechanics, stability & control, aerospace structures & materials, etc.) to perform an in-depth analysis and/or design of an aerospace engineering system taking into consideration economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints.

AE295B/AE299 – Fall 2016 – Prof. Periklis Papadopoulos

AE295B/AE299 – Spring 2016 – Prof. Periklis Papadopoulos

Assessment Summary: Overall, **Outcome B is satisfied** in the MSAE Program.

Performance Indicators for Outcome B

B.1 – Application of AE science (aerodynamics, propulsion, flight mechanics, stability & control, aerospace structures & materials, etc.).

B.2 – Perform an in-depth analysis and/or design of an aerospace engineering system.

Assessment Tool

Items B.1 and B.2 on the final MSAE project/thesis evaluation form.

Student Performance Results

	% students who scored 70% or higher (14/20)	
	Spring 2016	Fall 2016
	Enrolled = 10	Enrolled = 10
	Passed = 5 (56%)	Passed = 5 (56%)
B.1 – Application of AE science...	5 (100%)	5 (100%)
B.2 – In-depth analysis...	5 (100%)	5 (100%)

Analysis

Clearly, this is the most critical outcome in the MSAE Program. Project/thesis advisors work closely with students for two semesters to ensure that students apply aerospace engineering science principles – which they learn in their graduate courses – to perform an in-depth analysis and/or design of an aerospace engineering system at a level expected for graduate students. Students are required to submit two progress reports during each semester of their project/thesis course, plus a draft of their end-of-semester report. Students are given feedback by their project advisor as well as the course coordinator regarding the quality of their reports and are expected to implement improvements, as needed. All students who passed the course in 2016 scored 14 / 20 or higher on both performance indicators.

Students described with sufficient level of detail and depth their systems and subsystems. They determined possible solutions strategies to solve each problem encountered and justified their selected strategy with scientific evidence. They benchmarked their analysis tools and presented their results. However, two areas of weakness were noted in most reports: students (a) addressed only one or two of the constraints mentioned in Outcome B, and (b) did not mention possible future steps to extend their analysis / design to the next level.

Recommendations

- Final reports should include a section on “future work”, as needed to carry the project to the next level.
- Final reports involving the design of an aerospace vehicle or system should include a section addressing as many of the constraints listed in Outcome B as applicable.
- Outcome performance indicators will be added for Outcome B to address “future work” and

“design constraints” and the MSAE Project Evaluation Form will be modified accordingly.

Implementation: Fall 2017

Outcome E – Graduate level technical writing ability, including correct language and terminology, appropriate visuals, and summarizing key ideas

AE295B/AE299 – Fall 2016 – Prof. Kamran Turkoglu

AE295B/AE299 – Spring 2016 – Prof. Kamran Turkoglu

Assessment Summary: Overall, **Outcome E is satisfied** in the MSAE Program.

Performance Indicators for Outcome E

E.1 – Use clear, correct language and terminology while describing experiments, projects or solutions to engineering problems.

E.2 – Use appropriate graphs and tables following published engineering standards to present results.

Course Activities

Students perform two semesters (6 units) of graduate level research and/or design and/or development, involving aerospace engineering systems or components and submit a final project report. Students are encouraged to submit and present their work at student and/or professional conferences.

Assessment Tool

Items E.1 and E.2 on the final MSAE project/thesis evaluation form.

Student Performance Results

	% students who scored 70% or higher	
	Spring 2016	Fall 2016
	Enrolled = 10	Enrolled = 10
	Passed = 5 (56%)	Passed = 5 (56%)
E.1 – Correct language & terminology (scale: 0 – 20)	5 (100%)	5 (100%)
E.2 – Appropriate use of graphs and tables (scale: (0 – 10)	5 (100%)	5 (100%)

Analysis

Students receive effective mentoring from their faculty advisors and in general, by the time they graduate, their writing ability is good, as reflected in their final reports. Some students submit papers to professional conferences and journals, co-authored with their faculty advisors, thus meeting an even higher standard. Students are required to submit two progress reports during each semester of their project/thesis course, plus a draft of their end-of-semester report. Students are given feedback by their project advisor as well as the course coordinator regarding the quality of their reports, to ensure they have time to implement improvements, as needed.

Recommendation: None.

Implementation: N/A

Part C

(This table should be reviewed and updated each year, ultimately providing a cycle-long record of your efforts to improve student outcome as a result of your assessment efforts. Each row should represent a single proposed change or goal. Each proposed change should be reviewed and updated yearly so as to create a record of your department's efforts. Please add rows to the table as needed.)

Proposed Changes	Status Update
BSAE Performance Indicator A-1.3 (linear algebra) Spring 2016 – AE157: <ul style="list-style-type: none"> ▪ Perform diagnostic assessment in the beginning of the semester to test students' skills in linear algebra. ▪ Create reference material (e.g. notes, videos, etc.) to help students review fundamental linear algebra concepts and bring lagging students up to speed. 	Implemented Spring 2017
BSAE Performance Indicator A-3.2 (rigid body dynamics) Spring 2016 – AE140 <ul style="list-style-type: none"> ▪ Develop rigid body dynamics visualization tools as project topics. 	Implemented Spring 2017
BSAE Performance Indicator A-3.6 (stability & control) Fall 2016 – AE168 <ul style="list-style-type: none"> ▪ Present more example problems in class. ▪ Provide better student mentoring. ▪ More problems will be solved in problem solving sessions outside of class. ▪ Encourage collaborative learning to enhance students' analytical skills. 	Implemented Fall 2017
BSAE Outcome Element A-4 (open-ended problem solving) Spring 2016 – AE162 <ul style="list-style-type: none"> ▪ Present and discuss case studies in class to demonstrate the different requirements of airfoils designed for different airplanes. ▪ Present a parametric study in class, involving wing parameters, to illustrate how such studies can be used to optimize wing design. ▪ Add a step-by-step process to the class notes to guide students in their estimation of drag polars for an airplane in cruise, takeoff, and landing configurations, allowing also for compressibility drag if the plane operates at high speeds. 	Implemented Spring 2017
BSAE Outcome Element B-1 (design of experiments) Fall 2016 – AE160 <ul style="list-style-type: none"> ▪ Provide a summary of the relevant theory for separated flows around delta-winged aircraft and bodies of revolution at high angles of attack during lecture as well as in notes, along with references for further study. 	Implemented Fall 2017
BSAE Outcome Element B-4 (data interpretation) Fall 2016 – AE160 <ul style="list-style-type: none"> ▪ Provide more guidance in class on how to interpret the flow patterns observed in the water tunnel experiments. 	Implemented Fall 2017
BSAE Outcome E-1 (report writing) Fall 2016 – AE172 <ul style="list-style-type: none"> ▪ Implement an enhanced review of documentation standards. Minimum requirements are spelled out in the provided guidelines; however, additional discussion, with pertinent examples, should improve initial report outcomes. Review should focus on use of technical language and introductory to charting data in Excel & Matlab. ▪ All students produce a 3D printed part related to the overall system/project through rapid prototyping. 	Implemented Fall 2017
BSAE Outcome E-2 (oral presentations) Fall 2016 – AE171 / AE172 <ul style="list-style-type: none"> ▪ Increase the proportion of the oral presentation grade allotted to individual performance. 	Implemented Fall 2017

<p>MSAE Outcome B (Apply AE science to analyze / design...) Spring 2016 & Fall 2016 – AE295B/AE299</p> <ul style="list-style-type: none">▪ Final project/thesis reports should include a section on “future work”, as needed to carry the project to the next level.▪ Final project/thesis reports involving the design of an aerospace vehicle or system should include a chapter addressing as many of the constraints listed in Outcome B as applicable.▪ Outcome performance indicators will be added for Outcome B to address “future work” and “design constraints” and the MSAE Project Evaluation Form will be modified accordingly.	Implemented Fall 2017
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