

# **CRITERION 4.**

## **CONTINUOUS IMPROVEMENT**

### **A. Students**

#### **A.1 Improvements in Student Advising**

Before AY 2007–08, AE students were advised by either AE or ME faculty. This system resulted in several cases of incorrect advising by ME faculty, who are not familiar with the AE Program. For example, when students come for spring advising in the fall of their junior year, they sometimes fail to list on their Academic Advising Guide one of the required AE core courses, which are offered only in the spring semester; an ME advisor could easily miss such a course. As a result, students would be unable to take their capstone design sequence in their senior year and their graduation was delayed by an entire AY. In a few cases, when it was realized that the problem was incorrect advising rather than negligence on the part of the student, exceptions were made and students were allowed to take their senior design capstone sequence without a prerequisite. This problem was fixed in Spring 2007 when the Dean’s Office mandated that only full-time AE faculty would advise AE students.

#### **A.2 Raising the Minimum Grade Requirement**

Prior to Fall 2006, the minimum grade required for graduation was D- in all courses in the major with the exception of selected AE and ME core courses, in which a C- was required. As a result, a few students were graduating without achieving the minimum acceptable level of achievement (70%) for certain outcomes addressed in those courses. To eliminate this problem, the minimum grade requirement for graduation was changed to a C- in Fall 2006 for all courses. Hence, students who started in Fall 2006 or later must achieve a higher minimum level of performance than they did prior to the last ABET visit.

## B. Program Educational Objectives

As mentioned in Criterion 2, the BSAE PEO are normally reviewed periodically every three years, according to the process illustrated in Figure 2.1. Unfortunately, due to a breakdown in the MAE Department administration, this process has not been fully implemented since AY 2004–2005. Regarding the definition of the PEO, student input has been solicited through exit interviews on a regular basis. On the other hand, the first time alumni surveys were sent out since our last ABET visit was Summer 2010 and the AEAB did not convene between 2005 and 2011. A new AEAB was recently formed (Appendix F) and convened on April 6, 2011.

### *Student Exit Interviews*

Table 4.1 shows the number of graduating seniors interviewed from Spring 2007 through Spring 2010. The total number of responses summarized below is 41.

Table 4.1 – Number of graduating seniors interviewed

Spring 07	Spring 08	Spring 09	Spring 10
20	14	02	05

Three open-ended questions were used in these interviews. Two of the questions pertain to the BSAE curriculum and the BSAE Program in general and are discussed in Section D. The first question pertains to the definition of the BSAE PEO and is included below.

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

A summary of the most frequent student responses to this question is shown in Table 4.2. Whenever possible, student responses were grouped together. For example, if a student identified technical writing as one of the most important skills, his response was counted under “communication skills” as well as under “technical writing”. If, on the other hand, the student simply mentioned communication skills, then the response was counted only under “communication skills”. This explains why the number of responses in the various sub-categories does not add up to the total number shown next to each major category.

Table 4.2 – Summary of most frequent student responses to exit interview Question #1

Communication skills	<b>24</b>
<i>Technical Writing</i>	9
<i>Presentation skills</i>	7
AE fundamentals	<b>23</b>
<i>Aerodynamics</i>	5
<i>Design skills</i>	4
<i>Propulsion</i>	2
<i>Compressible Flow</i>	2
Team / interpersonal skills	<b>23</b>
Problem solving skills - creativity, improvisation, adaptability, critical thinking	<b>15</b>
Computer skills / Modern Tools	<b>14</b>
<i>CFD</i>	10
<i>CAD</i>	10
<i>Programming</i>	2
<i>Matlab</i>	2
Professional Development Skills	<b>8</b>
<i>Leadership</i>	4
<i>Motivation; taking initiative; drive</i>	4
<i>Time management, planning, multi-tasking</i>	3
<i>Perseverance; determination</i>	2
Manufacturing knowledge, skills	<b>7</b>
<i>Hands-on, building skills</i>	2
Lifelong learning skills	<b>5</b>
Project skills	<b>2</b>
Laboratory skills	<b>2</b>

Student responses to Question #1 validate PEO # 1, 2, and 3.

### *Alumni Surveys*

Alumni surveys were sent out in Summer 2010. Ninety-two (92) BSAE alumni graduated within the last 5 years and 13 responded to the survey, a return rate of 14%. Two of the respondents were unemployed. A summary of responses related to the PEO is shown below.

### *Evaluation of the PEO through Employment Data of BSAE Graduates*

Table 4.3 lists the companies in which the respondents worked at the time of the survey, Tables 4.4 and 4.5 list their current and previous job titles, and Table 4.6 summarizes their job responsibilities using more general descriptors, which match the PEO.

Table 4.3 – Companies, which employ recent BSAE alumni

<i>Company Name</i>	<i># of alumni employed</i>
Space Systems / Loral	3
NASA Ames Research Center	1
Lockheed Martin	1
Vibrynt Inc.	1
PGE	1
Salas O’Brien	1
Ford Motor Company	1

Table 4.4 – BSAE alumni current job titles

<i>Job Title</i>	<i># of alumni</i>	<i># of years on the job</i>
R&D Engineer	2	2 / 1.5
Satellite Operations Engineer	1	2
Small Satellite Intern	1	Less than 1
Systems Integration / Test Engineer	1	3
Product Development Engineer	1	5
Project Engineer	1	1.5
Field Engineer	1	Less than 1
Operations Engineer	1	3
Mechanical Engineer	1	2

Table 4.5 – BSAE alumni previous job titles

<i>Job Title</i>	<i># of alumni</i>	<i># of years on the job</i>
Operations Engineer	1	2
Entry Level Analyst	1	
Systems Engineer: Mass Management Lead	1	3
Automation Engineering Intern	1	2
Test Engineer	2	1.5
Mechanical Engineer	2	1
Associate Gas Engineer	1	2
Body Structures – Exterior Lighting	1	
Operations Clerk	1	1

Table 4.6 – BSAE alumni job responsibilities

	<i># of alumni</i>	<i>% of respondents</i>
Development	9	75%
Testing	9	75%
Design	6	50%
Research	5	42%
Manufacturing	4	33%
Administrative / Management	4	33%
Other	2	17%

The following observations can be made from Table 4.6:

- The largest percentage of our most recent graduates work in development (75%) and testing (75%), followed by design (50%), research (42%) and manufacturing (42%); 33% have administrative / management responsibilities. These data validate PEO#1.
- Although the number of surveys received is small, the types of jobs held by our graduates, indicates that our Program prepares them well for these positions.

Furthermore, 67% of the respondents felt that their engineering education at SJSU prepared them well for their career compared to their co-workers; 22% (2) were not sure and 11% (1) felt that this was not the case.

***Evaluation of PEO through M.S. Degree Enrollment and/or Completion Data***

None of the respondents had completed their M.S. or any other advanced degree at the time of the survey; however, six of them (46%) were enrolled in a graduate program, as follows:

- Three (23%) were enrolled in an MSAE (SJSU) or MS in Aeronautics & Astronautics program (Stanford University)
- One (8%) was enrolled in an MSME program (Santa Clara University)
- One (8%) was enrolled in a MS in General Engineering with emphasis in Materials Engineering (SJSU)
- One (8%) was enrolled in an MS in Engineering Management and Leadership program (Santa Clara University)

Furthermore, six of the respondents (46%) had received training or attended seminars / workshops since their graduation from SJSU. These data validate PEO#2.

Table 4.7 – Summary of alumni comments

The BSAE Program has excellent professors	4
<i>willing to help students understand complex concepts, willing to do whatever it takes to ensure graduates are well prepared, emphasize teamwork, a practice incredibly helpful in AE industry, compared with students from other campuses, AE grads from SJSU know the material and are willing to stand behind what they present</i>	
The BSAE Program does not have enough full-time faculty	2
Enjoyed part-time faculty from industry (Murbach, Djordjevic, Swei)	1

Table 4.8 – Summary of alumni recommendations

<i>Set up a fund to provide an initial amount of money to each senior design project (\$200-\$300)</i>	1
<i>AE labs need to be upgraded; add more labs</i>	2
<i>Introduce a programming course that focuses on general programming concepts rather than a specific language; teach C++, Java, Linux but not LABVIEW</i>	2
<i>Hire more full-time AE faculty; make sure they know how to teach a class</i>	1
<i>Replace CE and ME courses with more courses that focus on spacecraft</i>	1
Recommendations for new electives and / or short courses	
<i>The environment of space and its effect on spacecraft (thermal snap, out-gassing, lubrication of equipment, radiation, materials selection)</i>	1
<i>History &amp; current applications of UAV</i>	1
<i>Orbital mechanics</i>	1
<b><i>Linear algebra (already installed as a required course)</i></b>	1
<i>Vector calculus</i>	1
<i>Optical systems</i>	1
<i>Sensors</i>	2
<i>Aeroacoustics</i>	1
<i>Programming methodology</i>	1
<i>Satellite communications (antenna design)</i>	1
<i>Project management</i>	2
<i>Human factors</i>	1
<i>Aerospace biomedical</i>	1
<i>Machine shop class</i>	1
<i>Satellite design and operation</i>	1
<i>Attitude determination &amp; control systems</i>	1
<i>Electrical systems; lab with electrical budget</i>	1
Recommendations for short courses	
<b><i>ProEngineer (has been available as an elective)</i></b>	1
<i>Matlab</i>	1
<i>Geometric Dimensioning &amp; Tolerance</i>	1
<i>Engineering accounting</i>	1

Table 4.9 – Summary of alumni responses on the importance and achievement of the PEO

PEO		Agree	Not sure	Disagree
1, 3	The AE Program helped me improve my <i>interpersonal, team, and leadership skills</i> .	4 (40%)	5 (50%)	1 (10%)
1, 3	Interpersonal, team, and leadership skills <i>are important</i> for the kind of work I do.	9 (90%)	1 (10%)	0
1	The AE Program has given me strong <i>problem-solving skills</i> .	7 (70%)	3 (30%)	0
1	Problem-solving skills <i>are important</i> for the kind of work I do.	9 (90%)	1 (10%)	0
1	The AE Program has given me strong <i>design skills</i> .	6 (67%)	2 (22%)	1 (10%)
1	Design skills <i>are important</i> for the kind of work I do.	7 (70%)	2 (20%)	1 (10%)
1	The AE Program has given me strong skills for <i>hands-on laboratory work and testing</i> .	5 (56%)	2 (22%)	2 (22%)
1	Hands-on laboratory work <i>is important</i> for the kind of work I do.	8 (80%)	2 (20%)	0
2	The AE Program has given me a strong foundation for <i>graduate work</i> .	7 (78%)	2 (22%)	0
3	The AE Program has given me a <i>broad knowledge</i> as well as an <i>understanding of multicultural and global perspectives</i> in engineering, that allows me to work effectively with people from around the world.	4 (44%)	3 (33%)	2 (22%)
3	A broad knowledge as well as an understanding of multicultural and global perspectives in engineering <i>are important</i> for the kind of work I do.	6 (60%)	3 (30%)	1 (10%)
3	The AE Program has given me an <i>understanding of the ethical choices</i> inherent in the engineering profession to provide for issues such as public safety, concern for the environment, and respect for intellectual property.	6 (67%)	1 (11%)	2 (22%)
3	An understanding of the ethical choices inherent in the engineering profession to provide for issues such as public safety, concern for the environment, and respect for intellectual property <i>is important</i> for the kind of work I do.	7 (70%)	2 (20%)	1 (10%)

Alumni responses in Table 4.9 indicate that our PEO are important for the kinds of jobs they have and agree that the BSAE Program has prepared them well in all but three skill areas:

- a. Interpersonal, team, and leadership skills (40% agreement rating). A recommendation has been made regarding these skills and will be implemented in AY 2011-2012 (see discussion under assessment of Outcome 3D).
- b. A broad knowledge as well as an understanding of multicultural and global perspectives in engineering to work effectively with people from around the world (44% agreement rating). The low rating is rather surprising, as our General Education Program was thought to adequately address this area. Nevertheless this area is also addressed in AE171B (see discussion under assessment of Outcomes 3D and 3G) and will also be addressed in AE172B beginning in AY 2011-2012.
- c. Hands-on laboratory work and testing (56% agreement rating). The introduction of AE160 and the acquisition of a new wind tunnel in the Aerodynamics Lab in AY 2010-2011 has allowed the implementation of 5 additional experiments in the BSAE curriculum: four new experiments in the aerodynamics sequence (AE160, AE162) plus one new experiment in static longitudinal and directional stability (AE168), to be

implemented for the first time in Fall 2011. Furthermore, Ms. Hunter has developed new experiments for AE114, which were implemented in Spring 2010.

### ***Evaluation of the PEO through Advisory Board Input***

At our recent AEAB meeting, we asked the members of the Board (Appendix F) to define from their experience the “ideal engineer” in their company / organization, 3–5 years after graduation and in particular, to consider the following questions about this engineer:

1. What are his/her typical assignments, responsibilities and achievements?
2. What kinds of knowledge/skills does one need to be an "ideal engineer"?
3. How much of this knowledge/skill must come from the undergraduate experience?
4. How much of this knowledge/skill is typically acquired in the first few years as a practicing engineer?

A summary of their responses is shown below.

Question 1. *What are his/her typical assignments, responsibilities and achievements?*

- Engineers 3–5 years after graduation perform the majority of the work at any company.
- Responsibilities: Engineering jobs range from analysis (RF, thermal, structural, etc.) to manufacturing / test (top level with spacecraft or “unit/box” level). After 3-5 years in such a position, an engineer typically moves up to higher and higher responsibilities. The life cycle for commercial spacecraft is typically 2-3 years. So, an engineer fresh out of school, after 3-5 years should already have at least one satellite “under his/her belt”. Depending on how quickly this engineer has climbed the ladder, they are given a fairly high level of responsibility even after just one program, usually at a point of getting direct customer contact. Those engineers who report to a single spacecraft program typically assist a senior engineer during the first year or so. There after they are gradually given more responsibility and eventually are assigned “their own” program. Those engineers who work on “units” or “boxes” typically assist senior engineers at first and then become “responsible engineers” for a given box/unit within a year or so. In most cases, this type of engineer works with multiple programs, each using the same (or varying option) unit/box. Those engineers that support analysis groups work in the same way. They typically work under a senior engineer at first and then within a year or so, they gradually take over their own program. Most of these engineers support multiple programs. By the 3-5 year mark, the engineer has a good understanding of how the company and our customers work. Again, given the short life cycle of our programs, they are given a fairly high level of responsibility quite early, with access to senior engineers for support.
- Problem solving: Provides solutions to a variety of technical problems of moderate scope and complexity. May participate in, and contribute to, the resolution of problems of high complexity and visibility.

- Discretion and latitude: Expected to work under general supervision. Most work would follow established procedures, but critical thinking regarding the applicability of individual methods and appropriate deviations specific to the individual task are expected. His/her work will be reviewed for soundness of technical judgment and accuracy.
- Impact: Contributes to the completion of milestones associated with specific projects. Errors may cause delays in schedules and cause allocation of additional resources.
- Works independently; able to “pick something up and run with it”.

Question 2. *What kinds of knowledge / skills does one need to be an "ideal engineer"?*

- Good practical sense of engineering. There is a good place for theory, but for most of our work at this level, we are in need of application. A personal example: While being responsible for an R&D project, very early in my career, I needed to make a very thin plate. Not thinking much of manufacturability, I specified a 0.0001” plate with tight tolerances and other design features. The drawing looked great. I sent it out for a quote, and received no bids. I talked to one of the subcontractors about why they didn't bid on it, and their response was that my design could not be physically manufactured. Lesson learned... With more experience I have learned what is reasonable, and what can be pushed.
- Lifelong learning skills and the willingness for continuous learning. I still learn to this day. I think it is very hard for engineers to ask questions, as it shows a level of vulnerability, of “not knowing” something. It is hard to learn to overcome this. The old adage of “there is never a dumb question” is really true, especially in our ever-increasing cross-country and cross-cultural industry. Designs, manufacturing, and testing are different in Japan than those in Europe, sometimes even for the same application. So, the “ideal” engineer continues to learn and ask “why”, without considering his/her questions a show of weakness.
- Knowledge: Comfortable in the correct application of engineering principles, theories, concepts and techniques. Sufficiently experienced as to spot anomalies in the results and track down potential sources for such anomalies.
- Direction: Is motivated by his/her work. Has sufficient interest in the subject so as to study different ways of doing things. Does not require undue supervision to perform most of his regular work. Such an engineer would regularly contribute in the resolution of complex challenges with more experienced team members.
- Communication: The ability to communicate complex technical information in verbal and written form is paramount. Engineers are expected to communicate with each other as well as with customers and government authorities in order to effectively perform their jobs.
- Technical skills
  - Problem solving / troubleshooting
  - Design skills, including writing requirements, iteration, optimization, systems engineering
  - Design experiments, perform error / statistical analysis
  - Linear algebra
  - Finite Element Analysis

- Dynamics & control
- Flight mechanics
- Solid foundation of fundamentals
- Computer skills; programming – not important in what language
- Specialized knowledge is not expected; on-the-job training is provided for specific applications
- CAD skills: some of the members indicated that coming to work with CAD skills was important. Some even specified the particular software (ProE, SolidWorks, etc.). On the other hand, some members indicated that CAD knowledge is not assumed in their company; rather, the company takes responsibility to train engineers in CAD.
- A feel for numbers
- Communicate effectively with manufacturing
- Communication skills both written and oral, including presentation skills
- Team / interpersonal skills

Question 3. *How much of this knowledge/skill must come from the undergraduate experience?*

- Engineers coming out of school must have lots of lab and other hands-on experience. It is not necessary that all of this experience should come from their field of study. For example, knowing what a thermocouple does, having experience with an O-scope, a voltmeter, a caliper, really goes a long way. This is not to say that theory is not important. Rather, the theory must provide a strong base for practical knowledge. Further experience with summer coops and student club projects is great.
- Technical abilities: It is desired that students be exposed to an extensive set of common engineering terms and concepts so that they are familiar with them when they encounter them on the job for the first time. The recent graduate should have a broad feel for the subject (orders of magnitude, expected trends, etc.) For Loads and Dynamics, the recent graduate is expected to have a reasonable grasp of flight mechanics and mathematical fundamentals (lack of linear algebra knowledge is a red flag for many in the flight mechanics and structures fields, which rely heavily on linear analysis). If proper fundamentals are taught during undergraduate studies, then the initial job of training a new engineer becomes just another application of the engineering principles that they have practiced and demonstrated repeatedly in school.
- Communication skills: Written and verbal skills can be polished (proper terminology, common phraseology, etc.) during the first few years of on-the-job-training. However, basic writing and presentation skills are expected from the first day of employment.

Question 4. *How much of this knowledge/skill is typically acquired in the first few years as a practicing engineer?*

- With commercial spacecraft life cycles being only 2-3 years, there is a very steep learning curve. In the first few years, the amount of knowledge and skills acquired is tremendous. Because of this, young engineers can get quickly excited about their new career, even fresh out of school.

- It is understood that the specific technical skills required for each specialized job function (CFD, aero-structures, flight simulation, orbital mechanics, design, etc.) is limited to underlying fundamentals upon graduation. During the first 5 years an engineer is expected to produce results, but more importantly, to improve his confidence and be capable of continuous learning. At work, the new engineer will develop an increased feel for the subject. All specialized knowledge related to the specific function he/she performs, is expected to come from his/her work experience. For example, in my work as a Loads and Dynamics Engineer, a great deal of aerodynamics, control systems, structural dynamics, and fundamental mathematics was acquired over the span of employment.

In summary, the AEAB members confirmed that new engineers (3-5 years after earning their BSAE degree) in their companies / organizations are expected to:

- a. Work independently with some supervision, undertake a high level of responsibility, participate in multiple projects, and make significant contributions to each project.
- b. Have solid fundamentals in their field, design skills, design-of-experiment skills, knowledge of modern tools, design-for-manufacturing experience, and ability to solve problems / troubleshoot.
- c. Bring a lifelong learning attitude and lifelong learning skills to allow for continuous learning on the job.
- d. Communicate well orally and in writing and have good interpersonal/team skills to work with engineers and customers from around the world.

These comments certainly validate all three of our PEO.

In summary, all our constituents agree that the PEO defined are appropriate for our BSAE Program. Moreover, alumni input confirms that the AE Program is currently achieving these objectives.

## C. Student Outcomes

### C.1 Process for Outcome Assessment

The process for assessing each outcome is illustrated in Figure 4.1.

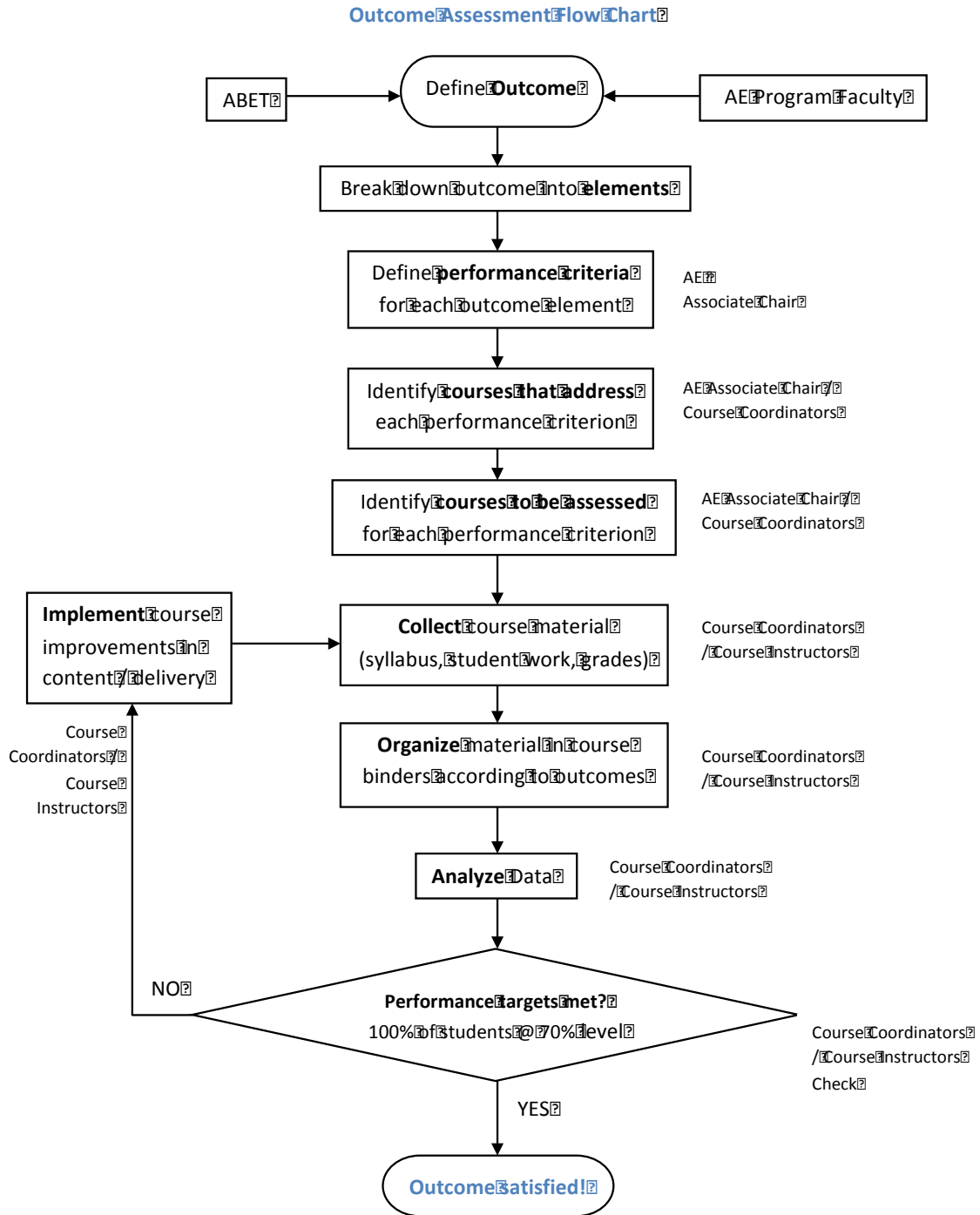


Figure 4.1 – Outcome assessment flow chart.

The AE Associate Chair coordinates the assessment of all the BSAE student outcomes. Because outcomes are rather comprehensive and difficult to assess as stated, we have analyzed each outcome into *outcome elements*. These elements represent the different abilities specified in a single outcome that would generally require different assessment measures. The process of dividing outcomes into elements allows for sufficient resolution in the assessment of each outcome. Moreover, it makes possible the effective implementation of specific course and curriculum improvements that address areas of concern.

Furthermore, for each outcome element we have defined *performance criteria*, i.e. student actions that explicitly demonstrate mastery of the abilities specified in an outcome element. These criteria are categorized using the 6 levels of Bloom’s taxonomy in the cognitive domain or 5 levels in the affective domain. In several outcomes where the embedded skills were unclear, we introduced rubrics to facilitate the assessment of the performance criteria associated with a particular outcome element. The BSAE Student Outcomes analyzed into elements and performance criteria are shown in Table 4.10.

Table 4.10 – Student outcomes, outcome elements and performance criteria

3A: Ability to use mathematics, science, and engineering principles to identify, formulate and solve aerospace engineering problems.			
<i>Outcome Elements: Ability to...</i>			
3A-1: Apply mathematics.	3A-2: Apply physics.	3A-3: Apply engineering principles.	3A-4: Identify, formulate and solve AE problems.
<i>Performance Criteria</i>	<i>Performance Criteria</i>	<i>Performance Criteria</i>	<i>Performance Criteria</i>
3A-1.1: Apply calculus	3A-2.1: Draw free–body diagrams	3A-3.1: Apply structures principles	3A-4.1: Engage in the solution of problems (spend adequate time on task, ask questions, etc.).
3A-1.2: Derive and use differential equations	3A-2.2: Apply Newton’s laws of motion	3A-3.2: Apply rigid body dynamics principles	3A-4.2: Define (open-ended) problems in appropriate engineering terms.
3A-1.2: Use linear algebra	3A-2.3: Apply physics concepts (e.g. angular momentum, friction, thermal / fluid concepts etc.)	3A-3.3: Apply aerodynamics principles	3A-4.3: Explore problems (i.e., examine various issues, make appropriate assumptions, etc.).
		3A-3.4: Apply flight mechanics principles	3A-4.4: Develop a plan for the solution (i.e., select appropriate theories, principles, approaches).
		3A-3.5: Apply propulsion principles	3A-4.5: Implement the solution plan and check the accuracy of calculations.
			3A-4.6: Evaluate results and reflect on personal strengths and weaknesses.

3B: Ability to design and conduct water tunnel and wind tunnel experiments, as well as to analyze and interpret data from such experiments.			
<i>Outcome Elements: Ability to...</i>			
3B-1: Design H <sub>2</sub> O and wind tunnel experiments.	3B-2: Conduct H <sub>2</sub> O and wind tunnel experiments.	3B-3: Analyze data from H <sub>2</sub> O and wind tunnel experiments.	3B-4: Interpret data from H <sub>2</sub> O and wind tunnel experiments.
<i>Performance Criteria</i>	<i>Performance Criterion</i>	<i>Performance Criterion</i>	<i>Performance Criteria</i>
3B-1.1: Define goals and objectives for the experiment.	3B-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.	3B-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.	3B-4.1: Given a set of results in tabular or graphical form, make observations and draw conclusions regarding the variation of the parameters involved.
3B-1.2: Research relevant theory and published data from similar experiments.			3B-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.
3B-1.3: Select the dependent and independent variables to be measured.			
3B-1.4: Select appropriate methods for measuring/controlling each variable.			
3B-1.5: Select a proper range for the independent variables.			
3B-1.6: Determine an appropriate number of data points for each type of measurement.			

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

3D: Ability to collaborate with people from different cultures, abilities, backgrounds, and disciplines to complete aerospace engineering projects.
<i>Performance Criteria</i>
3D-1: Committed to the team and the project, dependable, faithful, reliable. Attends all meetings; arrives on time or early. Comes to the meetings prepared and ready to work.
3D-2: Leadership: takes initiative, makes suggestions, provides focus. Creative, brings energy and excitement to the team. Has a “can do” attitude. Sparks creativity in others.
3D-3: Gladly accepts responsibility for work and gets it done; spirit of excellence.
3D-4: Has abilities the team needs. Makes the most of these abilities. Gives fully, doesn’t hold back.
3D-5: Communicate ideas clearly when speaking and writing. Understands the direction of the team.
3D-6: Personality: positive attitudes, encourages others, seeks consensus, brings out the best in others.

3E: Ability to communicate effectively through technical reports, memos, and oral presentations as well as in small group settings.	
<i>Outcome Elements: Ability to ...</i>	
3E-1: Communicate in writing	3E-2: Communicate orally
<i>Performance Criteria</i>	<i>Performance Criteria</i>
3E-1.1: Produce well-organized reports, following guidelines.	3E-2.1: Give well-organized presentations, following guidelines.
3E-1.2: Use appropriate graphs and tables following published engineering standards to present results.	3E-2.2: Make effective use of visuals.
3E-1.3: Use clear, correct language and terminology while describing experiments, projects or solutions to engineering problems.	3E-2.3: Present the most important information about a project / experiment, while staying within allotted time.
3E-1.4: Describe accurately in a few paragraphs a project / experiment performed, the procedure used, and the most important results (abstracts, summaries).	

3F: Understanding of professional and ethical responsibility.
<i>Performance Criterion</i>
Given a job-related scenario that requires a decision with ethical implications students can identify any ethical issues raised by reference to professional codes of ethics (e.g. NSPE, ASME), identify possible courses of action, discuss the pros and cons of each course of action, decide what is the best course of action, and justify their decision.

3G: Broad education to understand current events, how they relate to aerospace engineering, as well as the impact of aerospace engineering solutions in a global and societal context.
<i>Performance Criteria</i>
3G-1: Identify regional, national, or global contemporary problems that involve aerospace engineering.
3G-2: Discuss possible ways aerospace engineering could contribute to the solution of these problems.
3G-3: Discuss the impact of AE in a global and societal context.

3H: Recognition of the need for, and ability to engage in life-long learning.
<i>Performance Criteria</i>
3H-1: Develop a process for learning, reflect regularly on this process, identify their strengths and weaknesses, and take the necessary steps to improve their learning process.
3H-2: Access information effectively and efficiently from a variety of sources.
3H-3: Research and learn new material on their own by reading articles, books, contacting experts, etc.

3I: Ability to use the techniques, skills, and modern engineering tools (analytical, experimental, and computational) necessary for aerospace engineering practice.
<i>Performance Criteria</i>
3I-1: Use modern software to conduct computer simulations, parametric studies, and ‘what if’ explorations.
3I-2: Use modern equipment and instrumentation in AE laboratories.

Although each performance criterion may be addressed in several required BSAE core courses, only a subset of these courses is selected for the assessment of each outcome/performance criterion, as shown in Table 4.11.

Table 4.11 – Required BSAE courses in which outcomes are assessed

BSAE	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)
<b>Required Courses</b>									
Engr. 100W					+++				
AE 114	++	(		(	(			(	
AE 140	++			(				(	
AE 160	++	++	(	(	+++		(	(	+++
AE 162	++	++	(	(	+++		(	++	+++
AE 164	++	(	(	(	(		(	(	
AE 165	++		(	(	(		(	(	
AE 167	++		(	(	(		(	(	
AE 168	(			(				(	
AE 169	++			(				(	+++
AE 171 A, B AE 172 A, B	(	(	+++	+++	+++	+++	++	+++	+++
Extra Curriculum 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

The various levels of competency according to Bloom’s Taxonomy are shown in Tables 4.12 and 4.13 respectively for the cognitive (Bloom, 1984) and affective (Bloom, Karthwohl, and Massia, 1984) domains.

Table 4.12 – The 6 levels of competency in the cognitive domain

Level	Competence	Description
1	Remember	Recognize or recall information (ex. repeat verbatim definitions or principles).
2	Understand	Understand the meaning of information, so they can explain it to others (ex. share their own examples of how a principle applies in certain situations).
3	Apply	Use information appropriately to solve well-defined problems.
4	Analyze	Deal with ambiguity in new, ill-defined situations by formulating models and seeing relationships.
5	Evaluate	Judge the worth of ideas, theories and opinions, choose among alternatives, and justify their choice based on specific criteria.
6	Create	Combine elements in novel ways to generate new products or

(Design)	ideas.
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Table 4.13 – The 5 levels of competency in the affective domain

Level	Competence	Description
1	Receive (a stimulus)	Go to class, participate in class activities.
2	Respond (to a stimulus)	Study for their courses, carry out assignments.
3	Value (a behavior)	Be committed to their education, have positive attitudes about their coursework.
4	Organize (values into a system)	Balance responsibilities effectively; begin to formulate a systematic approach to learning.
5	Characterized (by a value system)	Work independently and diligently, practice cooperation when working in teams, act ethically. Their value system reflects consistently in their behavior.

To satisfy Criterion 3, we have defined our *performance target* as follows:

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

### **Gateway Assignments**

To ensure that all students meet the minimum performance requirement and thus achieve the performance target of 100% in each outcome, gateway assignments are being implemented in key required courses. Students must receive a minimum score of 70% in these assignments to pass the course, regardless of their performance in other course assignments or exams. The gateway assignments implemented in AY 2010-2011 are shown in Table 4.14.

Table 4.14 – Gateway assignments

Outcome 3B	AE 160	4 – Lab Reports
	AE 162	4 – Lab Reports
Outcome 3C	AE 171A&B	12 Design Reports
	AE 172A&B	03 Design Briefings
Outcome 3E	Engr. 100W	Exit Exam
	AE 171A&B	03 Design Briefings
	AE 172A&B	
Outcome 3F	AE 171A&B	4 – Case Studies with related assignments
	AE 172A&B	
Outcome 3G	AE 171A&B AE 172A&B	2 – Research Papers / Presentations

## **C.2 Course Assessment**

Figure 4.1 shows the process for assessing each of the selected courses. Course coordinators assess their courses for the specific outcomes they address, as indicated in

table B.3.3. They are responsible for ensuring that performance targets are met for each outcome in each of their courses. If the target for a particular outcome is not met, they make recommendations for improvements in that area and take responsibility for implementing these improvements in the course. If they do not teach the particular course, they coordinate the changes with the faculty who teach the course. After the implementation of the improvements, coordinators re-assess the course and re-evaluate student performance against the targets.

**C.3 Timeline**

The intended timeline for the assessment of the BSAE Outcomes is shown in Table 4.15. Each outcome was to be assessed periodically every 3 years. Since BSAE courses are offered once a year, after an outcome is assessed, course and/or curriculum improvements would be implemented for 3 consecutive course offerings, at which time the faculty would have an opportunity to flash out any problems or inefficiencies. Then at the third offering of the outcome would be re-assessed.

Table 4.15 – Intended timeline for BSAE Outcome Assessment

Outcomes									
	3A	3B	3C	3D	3E	3F	3G	3H	3I
Spring 06	X					X			
Fall 06		X					X		
Spring 07			X					X	
Fall 07				X					X
Spring 08					X				
Fall 08						X			
Spring 09	X						X		
Fall 09		X						X	
Spring 10			X						X
Fall 10				X	X				
Spring 11	Finalize BSAE Self-Study Report								
Fall 11	ABET Visit								

**C.4 Outcome Assessment**

**Outcome 3A – Ability to apply mathematics, science, and engineering principles to identify, formulate and solve AE problems**

**Outcome Assessment Summary:** The performance target is not met for Outcome 3A.

**Course Statistics**

Course	Semester	Faculty Member	Enrollment	# of students who passed	% of students who passed
AE 162	Spring 2007	Dr. Nikos J. Mourtos	24	23	96%
AE 164	Fall 2009	Dr. Nikos J. Mourtos	26	25	96%
AE 114	Spring 2010	Ms. Jeanine Hunter	22	21	95%
AE 140	Spring 2010	Ms. Jeanine Hunter	25	23	92%

AE 162	Spring 2010	Dr. Nikos J. Mourtos	28	23	82%
AE 160	Fall 2010	Dr. Nikos J. Mourtos	24	15	63%
AE 164	Fall 2010	Dr. Nikos J. Mourtos	15	14	93%
AE 165	Spring 2010	Dr. Periklis P. Papadopoulos			
AE 167	Spring 2010	Dr. Periklis P. Papadopoulos			

**3A-1: Ability to apply mathematics.**

*Courses Assessed: AE 140, AE 160, AE 162*

**Recommendation**

Following the curriculum change in AY 10-11 to require Linear Algebra (Math 129A) in the BSAE curriculum, the “ability to use linear algebra in the solution of AE problems” should be included as an element of this outcome and assessed in AE169 (CFD), which now has Math 129 as a prerequisite.

**Implementation:** Spring 2011

**Performance Criterion 3A-1.1: Ability to apply calculus.**

*Courses Assessed: AE 140, AE 160, AE 162*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-1.1.

*AE140 – Spring 2010 – Ms. Jeanine Hunter*

**Assessment Summary:** The performance target is not met.

**Course Activities**

Differentiate a vector in a rotating reference frame to obtain inertial acceleration. This involves calculus and vector algebra.

**Assessment Tools:** One problem on Exam 1 and one problem on the Final Exam.

**Student Performance Results**

	Students who scored 70% or higher
Exam 1	88%
Final Exam	85%

**Analysis**

Students who fail to apply calculus correctly usually either apply the chain-rule incorrectly or make careless errors, both of which can be easily corrected. Students who are weak in calculus sometimes become overwhelmed with the complexity of dynamics problems and make unnecessary mistakes. Working carefully through many problems will help them to navigate all aspects of these difficult problems.

**Recommendations**

- Employ more opportunities for in-class, co-operative learning exercises, during which I will coach students in a small group setting.

- Give multiple homework assignments, which exercise the concept of writing the equations of motion of a complex system with multiple reference frames. These assignments will help students build their skill of representing vectors in an arbitrary reference frame as well as differentiating and integrating in a rotating reference frame.

**Implementation:** Spring 2011

*AE160 – Fall 2010 – Dr. Nikos J. Mourtos*

*AE162 – Spring 2007 & 2010 – Dr. Nikos J. Mourtos*

**Assessment Summary:** The performance target is not met.

**Course Activities (AE 160)**

- Integrate surface pressure / shear stress distributions to calculate normal, axial, lift, and drag force coefficients.
- Use the integral form of the continuity and momentum equation to calculate the average velocity in a cross-section of the flow and the drag of 2-D bodies from wake profiles.
- In addition to solving problems in class, students use these skills in their lab reports to calculate (a) lift from measured pressure distributions on an airfoil at different angles of attack and (b) drag from measured wake profiles on an airfoil at different angles of attack.

NB: The topics and course learning objectives associated with this outcome element were originally in AE162. Starting in Fall 2010, AE160 was introduced as Aerodynamics I and these topics and associated skills are now taught in AE160.

**Course Activities (AE 162)**

- Calculate the divergence and the curl of the velocity vector for various flow fields to determine whether a flow satisfies continuity and / or is irrotational.
- Differentiate stream functions and velocity potential functions to derive the velocity functions of various flow fields.
- Integrate velocity vectors around closed paths to calculate circulation.

**Assessment Tools:** One problem on Midterm 1 and one problem on Midterm 2.

**Student Performance Results**

	Students who scored 70% or higher	
	Problem 1, Midterm 1	Problem 1, Midterm 2
AE 160 – Fall 2010	73%	N/A
AE 162 – Spring 2007	70%	100%
AE 162 – Spring 2010	87%	100%

**Analysis**

The data show that not all the students who receive a passing grade in the course meet the performance target in this performance criterion. 25% - 30% of our juniors are deficient in their ability to integrate simple functions. The higher success rate of 87% in Spring 2010 occurred only because students were given two consecutive makeup exams for their first midterm, in which performance criterion 3A-1.1 was assessed. It should be noted

that when they solve problems that involve the calculation of aerodynamic forces, whether by integration of the pressure and shear stress distribution or application of the momentum equation, students apply the aerodynamics equations correctly. It is their inability to integrate correctly that prevents them from getting the correct answer in various problems.

On the other hand, 100% of the students demonstrate adequate proficiency (score 70% or better) in performing the calculus-related tasks listed above for AE162. Students who do not solve potential flow theory problems correctly fail because of their lack of understanding of the concepts, not because of their inability to perform the calculus. This is further discussed under performance criterion 3A-3.3 below.

***Recommendation***

AE faculty should meet with the coordinator of the Calculus series to discuss ways for improving student performance in this area.

***Implementation:*** AY 2011-2012

**Performance Criterion 3A-1.2:** *Ability to derive and solve ODE.*

*Course Assessed: AE140 – Spring 2010 – Ms. Jeanine Hunter*

***Assessment Summary:*** The performance target is not met.

***Course Activities***

- a. Derivation of 2<sup>nd</sup>-Order ODE for the position of a particle moving over the surface of the rotating Earth. Students derive coupled 2<sup>nd</sup>-Order ODE in the translational positions relative to a reference frame fixed to the surface of the Earth. Then they simplify the equations so they can be solved closed-form.
- b. Numerical integration of rigid body (differential) equations of motion using various algorithms and integration step sizes.

***Assessment Tool:*** One problem on Exam 1.

***Student Performance Results:*** 75% of the students scored 70% or higher.

***Analysis***

Derivation of the differential equations which model the motion of a particle with respect to the Earth is a complex, multi-step problem. It takes some students a while to fully grasp the concept; then it is another big step to write the differential equations; and yet another leap to carefully perform all of the steps necessary to decouple and solve the equations. Strong students grasp these ideas immediately and competently carry out the steps. Although I work through examples in class and give homework on this topic, some students fail to learn sufficiently well to be able to carry out the integration correctly.

***Recommendation***

Have the students work this type of problem as a small group exercise, so I can evaluate their individual needs for remedial work.

**Implementation:** Spring 2011

**3A-2: Ability to apply physics.**

*Courses Assessed: AE 114, AE140,*

**Performance Criterion 3A-2.1: Ability to draw free-body diagrams.**

*Course Assessed: AE114 – Spring 2010 – Ms. Jeanine Hunter*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-2.1.

**Course Activities**

- a. Construction of the shear force and bending moment diagrams by making imaginary cuts in the beam and drawing a free-body diagram of each beam section (method of sections).
- b. Creating a free-body diagram of each node of a spacecraft truss (pin joints carry no moment, so this diagram includes only applied and reaction forces).

**Assessment Tool:** One problem on the Final Exam.

**Student Performance Results:** 91% of the students scored 70% or higher.

**Analysis**

Students who failed to meet this criterion did not construct the free body diagram correctly, i.e. did not include all the forces / moments or the appropriate forces / moments in the diagram. Students who constructed the free body diagram correctly usually solved it correctly. The perception of the conditions of static equilibrium seems to be the stumbling block in this type of problem, not the ability to do the arithmetic to solve for the unknown forces / moments. This is a high level concept, but one that is usually well taught in the Strength of Materials prerequisite.

**Recommendation**

Spend some extra time in review, specifically requiring students to solve this type of problem in class, so I can reinforce the concepts as needed.

**Implementation:** Spring 2011

**Performance Criterion 3A-2.2: Ability to apply Newton's laws of motion.**

*Course Assessed: AE140 – Spring 2010 – Ms. Jeanine Hunter*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-2.2.

**Course Activities**

- a. Derive the translational equations of motion (of a particle or center of mass of a rigid body) moving in inertial space and observed in either a Newtonian or non-Newtonian reference frame.
- b. Identify  $n$  and use Coriolis and centripetal acceleration components in solving problems of particle motion over the surface of the Earth.

- c. Predict the difference between inertial and relative motion and model this motion with Newton’s Laws.
- d. Derivate 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).
- e. Use the equations of rotational motion to model a spin-stabilized missile.

**Assessment Tools**

One problem on Exam 1, one problem on Exam 2, and one problem on the Final Exam.

**Student Performance Results**

Students who scored 70% or higher		
Problem on Exam 1	Problem on Exam 2	Problem on the Final Exam
63%	55%	50%

**Analysis**

Failures in this area of learning fall into two categories: First, students are sometimes deficient in their understanding of the physics concepts which underlie rigid body dynamics. Second, even though they understand physics and elementary dynamics, some students have difficulty with complex, three-dimensional dynamics problems – especially those which model rotational motion.

**Recommendations**

- Employ more opportunities for in-class, co-operative learning exercises, during which I will coach students in a small group setting.
- Give multiple homework assignments, which exercise the concept of writing the equations of motion of a complex system with multiple reference frames. These assignments will help students build their skill of representing vectors in an arbitrary reference frame as well as differentiating and integrating in a rotating reference frame.

**Implementation: Spring 2011**

**Performance Criterion 3A-2.3:** *Ability to apply physics concepts (ex. angular momentum, friction, thermal / fluid concepts etc.).*

*Course Assessed: AE 140 – Spring 2010 – Ms. Jeanine Hunter*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-2.3.

**Course Activities**

- a. Use conservation of angular momentum to model the despinning of a satellite.
- b. Use the change in angular momentum to derive Newton’s rotational equations of motion.
- c. Explain the role of friction and gravitational torque in maintaining the steady precession of a top.
- d. Apply the principle of impulse and momentum to derive the equations of motion of a spacecraft struck by a micro-meteorite.

**Assessment Tool:** One problem on Exam 2.

**Student Performance Results:** 89% of the students scored 70% or higher.

**Analysis**

Students who failed to meet this criterion did not understand the relationship between moments / forces and dynamic response. For example, in the problem of a spacecraft struck by a micrometeorite, the students write an expression for the impulse of the micrometeorite strike and the resulting moment on the spacecraft. From that expression, they then derive the change in angular momentum and the ensuing coning motion. Though the mathematics of this kind of problem is fairly straightforward, the spacecraft dynamics are complex physically. For the students, the difficulty is usually in visualizing the three dimensional motion.

**Recommendation**

Do more visualization exercises using well-constructed diagrams and 3-D models.

**Implementation:** Spring 2011

**3A-3: Ability to apply aerospace engineering principles.**

*Courses Assessed: AE 114, AE140, AE160, AE162, AE164, AE165, AE167*

**Performance Criterion 3A-3.1: Ability to apply principles of aerospace structures.**

*Course Assessed: AE114 – Spring 2010 – Ms. Jeanine Hunter*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-3.1.

**Course Activities**

- a. Use area properties of a wing section to calculate the orientation of the principal axes, and thereby the principal stresses.
- b. Calculate shearing strain/stress and angle of twist of a beam / circular shaft / aircraft tail section subject to a torsional load. Use the torsional beam in the lab to verify this result experimentally.
- c. Calculate shear flow in a multiple cell wing section, satisfying both the angle of twist compatibility condition and the equations for static equilibrium.
- d. Compute the symmetrical and nonsymmetrical bending stresses on a wing section. Symmetrical bending stresses are also determined experimentally on the cantilever beam.
- e. Calculate the stiffness matrix, nodal displacements and axial force for a three-bar truss element of a spacecraft structure.

**Assessment Tools:** 3 problems on the Final Exam.

**Student Performance Results**

Students who scored 70% or higher		
Final Exam, Problem 1	Final Exam, Problem 2	Final Exam, Problem 3
91%	73%	91%

***Analysis***

Most of the failures in this criterion were the result of students not completely learning concepts presented in AE114, rather than a lack of preparation from the prerequisites. For example, the idea of shear flow is a new concept in AE114 and incorporating shear flow into a force / moment balance can be challenging for the students. Failures usually occurred when analyzing the more complex structural elements, e.g. a multi-cell wing section subjected to torsion in which compatibility must be maintained.

***Recommendation***

Assign more homework problems preceded by more focused discussion during class time.

***Implementation:*** Spring 2011

**Performance Criterion 3A-3.2:** *Ability to apply rigid body dynamics principles.*

*Course Assessed: AE 140 – Spring 2010 – Ms. Jeanine Hunter*

***Assessment Summary***

The performance target is not met for Performance Criterion 3A-3.2.

***Course Activities***

Derive the equations of motion of a particle or rigid body using the energy methods or Lagrange’s Method. This involves finding the translational / rotational kinetic and potential energies of the particle / rigid body.

***Assessment Tools:*** One problem on the Final Exam.

***Student Performance Results:*** 81% of the students scored 70% or higher on this problem.

***Analysis***

Since Lagrange’s Method is an energy formulation, failure to write the Lagrangian correctly (the difference between kinetic and potential energies) accounted for the majority of the misunderstandings of this topic. Writing equations of motion using energy methods is a minority topic in AE140. I use the Newtonian formulations for almost the entire course since they are much more intuitive (i.e. position and velocity are more straightforward to visualize than kinetic energy) and therefore more appropriate for an undergraduate class. Nonetheless, undergraduate students should be able to formulate energy correctly and differentiate it to derive the equations of motion.

***Recommendation***

Work more problems using multiple methods, Newton’s Laws and Lagrange’s formulation, so that students will have confidence using either method. Doing more problems will also result in students developing better technical intuition about the correct equations of motion (regardless of method) for a particular problem.

***Implementation:*** Spring 2011

**Performance Criterion 3A-3.3:** *Ability to apply aerodynamics principles.*

*Courses Assessed: AE160, AE162, AE164 – Dr. Nikos J. Mourtos*

### ***Assessment Summary***

The performance target is not met for Performance Criterion 3A-3.3.

#### ***Course Activities*** (AE160)

- a. Calculate aerodynamic forces and moments on bodies by integrating surface pressure and shear stress distributions.
- b. Use flow similarity to design wind tunnel tests.
- c. Use the momentum equation to calculate (a) lift from given pressure distributions on the top and bottom of an aerodynamic body and (b) drag from given velocity profiles ahead and downstream of an aerodynamic body.
- d. Predict transition from laminar to turbulent flow on an aerodynamic surface.
- e. Calculate the skin friction drag and estimate the pressure drag of aerodynamic bodies.

NB: The topics and course learning objectives shown above, which pertain to this outcome element were originally in AE162. Starting in Fall 2010, AE160 was introduced as Aerodynamics I and these topics and associated skills are now taught and assessed in AE160.

#### ***Course Activities*** (AE162)

- a. Analyze the elementary flows (uniform, source / sink, doublet, vortex, corner) as well as combinations of them.
- b. Use experimental data, thin airfoil theory results, and computer programs to predict aerodynamic characteristics of airfoils (ex. lift and drag at various angles of attack, pitching moment about various points, ac location, etc.)
- c. Use the Biot-Savart law to calculate induced velocities in the vicinity of line vortices.
- d. Apply Prandtl's lifting-line theory to calculate the aerodynamic characteristics of airplane wings.
- e. Use the method of images to discuss and calculate aerodynamic interference for (a) wings flying in the vicinity of each other, (b) wind-tunnel boundaries, and (c) ground effects.

#### ***Course Activities*** (AE164)

- a. Use thermodynamics and conservation equations to calculate flow parameters at various points of a flow field.
- b. Calculate stagnation and critical conditions at various points of a flow field for isentropic flow, adiabatic flow, flow with heat addition and flow with friction.
- c. Calculate the flow properties downstream of a Mach wave, an oblique shock wave, a Prandtl-Meyer expansion wave, and a normal shock wave.
- d. Calculate the lift and drag coefficients on supersonic airfoils using shock - expansion theory.
- e. Calculate the flow properties downstream of a reflected / refracted shock wave.
- f. Calculate the flow conditions in a shock tube behind the incident and the reflected shock waves.
- g. Calculate the speed of the incident and the reflected shock waves in a shock tube.
- h. Calculate the location of a shock in a Laval nozzle (assuming there is one).

***Assessment Tools:*** Midterm and final exams in each course.

***Student Performance Results***

	Students who scored 70% or higher		
	Midterm 1	Midterm 2	Final Exam
AE 160 – Fall 10	12 (80%)	N/A	8 (53%)
AE 162 – Spring 07	18 (78%)	17 (74%)	13 (57%)
AE 162 – Spring 10	21 (91%)	15 (65%)	8 (35%)
AE 164 – Fall 09	25 (100%)	N/A	18 (72%)
AE 164 – Fall 10	11 (79%)	N/A	14 (100%)

Although all students need to demonstrate a minimum level of competence in each and every course to earn a passing grade, it appears that a large percentage of students fail to meet the 70% performance target in their exams. Several students compensate for their poor exam performance with a much better performance in their lab and project reports, both of which are required in all three courses. Since these assignments are performed in teams, however, they are not included in this analysis. Reasons contributing to students’ low performance on tests include:

- Poor understanding of the material / poor problem-solving skills.
- Inadequate preparation for the test.
- Poor study / test-taking skills.

It should be noted that at least 50% of the class time is dedicated to problem solving, including presentation of numerous example problems as well as problem solving in small groups. However, students either do not always follow up with further studying after each class and they do not practice additional problem solving on their own.

***Recommendation***

Offer weekly problem solving workshops to give students additional opportunities for practice. These workshops can be offered by Sigma Gamma Tau students, who will be trained by faculty, with an emphasis on coaching students to solve problems on their own rather than presenting solutions. These workshops will be mandatory for students at risk (e.g. low grades in prerequisites) or students who perform below the target (70%) at any test during the course of the semester.

***Implementation:*** AY 2011-2012

**Performance Criterion 3A-3.4:** *Ability to apply flight mechanics principles.*

*Course Assessed: AE165 – Spring 2010 – Dr. Periklis P. Papadopoulos*

***Assessment Summary***

The performance target is not met for Performance Criterion 3A-3.4.

***Course Activities***

- a. Estimate aircraft performance.
- b. Use performance characteristics of propulsion systems to predict aircraft performance.
- c. Quantify the impact of aircraft design characteristics on performance.
- d. Analyze hypersonic vehicle reentry.
- e. Calculate satellite orbits.
- f. Compute multi-stage launch vehicle performance.

**Assessment Tools:** Midterm exam and final project report.

**Student Performance Results**

Students who scored 70% or higher	
Midterm Exam	Final Project Report
77%	83%

**Recommendation**

Offer weekly problem solving workshops to strengthen student understanding of flight mechanics. These workshops will be offered by the AIAA Student Chapter and recommended for students at risk (e.g. low grades in prerequisites) or students who perform below the target (70%) at any test during the course of the semester.

**Implementation:** Spring 2011

**Performance Criterion 3A-3.5:** *Apply propulsion principles.*

*Course Assessed: AE167 – Fall 2010 – Dr. Periklis P. Papadopoulos*

**3A-4: Ability to identify, formulate and solve AE problems.**

*Courses Assessed:*

*AE162 – Spring 2008 & 2009 – Dr. Nikos J. Mourtos*

*AE165 – Spring 2008 & 2009 – Dr. Periklis P. Papadopoulos*

**Course Design to Address Outcome Element 3A-4**

Several core BSAE courses have been re-designed in an effort to help students develop problem-solving skills. This re-design includes:

- a. Explicit definition of skills and attributes that students need to develop to become capable problem-solvers.
- b. Inclusion of open-ended problems (OEP) in each of several key, junior-level, core courses.
- c. Coaching students in the use of Wood’s Problem-Solving Methodology (PSM). This process includes seven steps (Woods, 1994):

Step 1: Engage

Step 2: Define

Students try to understand the problem and re-state it in their own terms. They make a comprehensive list of what is given but also what may be known from other sources, and determine any applicable constraints. This step requires some research on the background of the problem. This may include reading various sections of the textbook, a visit to the library or searching online (students’ favorite method). Students are expected to draw a sketch of how they visualize the problem including any parameters they think relevant. The most important outcome of this step is the criterion to be used in answering the question in the problem.

**Step 3: Explore**

Students explore relevant questions and brainstorm possible ways to model the physical situation described in the problem by making appropriate assumptions. To develop intuition, students attempt to predict the answer to the problem.

**Step 4: Plan**

Students select an appropriate model (usually the simplest available) for developing a solution. They break down the problem into smaller sub-problems, each involving the calculation of various parameters, which serve as stepping-stones towards the final answer. It is important that students develop an algorithm (flow chart) for the solution of the problem and not substitute any numerical values. This algorithm may involve, for example, identifying appropriate equations or graphs for calculating various parameters in each sub-problem.

**Step 5: Implement**

This is the most straightforward step of the PSM. Students substitute the values of known and assumed quantities into their model (equations) and develop the solution, checking for accuracy and consistency of units. The outcome of this step includes numerical answers for various parameters and usually includes additional sketches, figures or drawings.

**Step 6: Check**

Students check their calculations for errors and make sure the units in all parameters are correct. No rubric is used to evaluate student performance in this step. Unchecked calculation errors simply result in lower scores in Step 5.

**Step 7: Reflect.**

Making an unrealistic assumption in Step 3 or choosing an inappropriate model in Step 4 often results in numbers that do not make sense. This is a common occurrence in OEP solving even among experienced problem solvers. Students are expected to identify the cause of the problem and correct it or suggest a more sophisticated approach to solve the problem. Furthermore, they compare their answer to their guesstimate from Step 3. If their guesstimate was incorrect they provide an explanation as a way of developing intuition. In addition to discussing the solution of the problem itself students reflect on their own strengths and weaknesses in the problem solving process.

- d. Development of rubrics to evaluate student performance for each step of this methodology (Mourtos, 2010)

***Course Activities***

In each of these courses students:

- a. Are presented with an example of an OEP and its detailed solution following the PSM.
- b. Work in teams to solve two OEP, using the PSM.
- c. Work in teams to identify, research, formulate, and solve a current multi-disciplinary problem that involves applications from at least two courses, AE162 / AE165 in the

spring of their junior year and AE164 / AE167 in the fall of their senior year. Students typically take each course pair concurrently. Students are encouraged to integrate applications from other courses that are taking or have completed in previous semesters (Mourtos, Papadopoulos, and Agrawal, 2006).

**Performance Criterion 3A-4.1:** *Willingness to engage in the solution of problems (spend adequate time on task, ask questions, etc.).*

**Assessment Summary:** The performance target is met for Performance Criterion 3A-4.1.

**Assessment Tool & Student Responses (N = 22)**

**Rubric for measuring student engagement (Step 1 of the PSM)**

How often have you done each of the following in connection with one of the OEP or course project?	Never	1 or 2 times			3 to 5 times	More than 5 times
1. Asked questions related to an OEP during class	22%	55%			14%	9%
2. Contributed to a class discussion related to an OEP	28%	41%			27%	4%
3. Prepared two or more drafts of the solution of these problems before turning them in	41%	36%			23%	0
4. Worked with classmates outside of class to prepare OEP solutions	14%	9%			36%	41%
5. Helped other students with the solution of OEP	23%	50%			18%	9%
6. Used an electronic medium (listserv, chat group, Internet, instant messaging, etc.) to discuss OEP solutions	32%	0			23%	45%
7. Used email to communicate with the course instructor regarding OEP	50%	19%			27%	4%
8. Visited the course instructor in his office to discuss OEP	28%	36%			27%	9%
9. Discussed ideas related to OEP with others outside of class (students, family members, coworkers, etc.)	46%	18%			18%	18%
10a. I found the wing / tail problem:	Not at all interesting	So – so (lukewarm about it)			Very Interesting / Engaging	
	14%	68%			18%	
10b. I found my project:	9%	50%			41%	
11. I worked harder than I normally do to solve the OEP in AE162	Never / Rarely	Sometimes			Very Often	
	4%	45%			46%	
12. I spent a total of ___ hours working on the wing/tail problem (alone, with my teammates, with the instructor) [Average =6.6 hours]	# of hours	1-2	3-4	5-7	8-12	15-30
	# of students	27%	14%	32%	14%	13%
13. How interested are you in learning the AE162 material?	Uninterested	So-so (lukewarm about it)			Very interested	
	0	14%			86%	
14. How difficult is the course material for you?	Difficult	Average Difficulty			Easy	
	32%	68%			0	

***Analysis***

The Table above shows a fairly good level of student engagement (students averaged 6–7 hours on each OEP). Students averaged 38 hours on their open-ended project, which represents a significant investment of time. There are three possible explanations for this: (a) the project requires integration of two subjects, aerodynamics (AE162) and flight mechanics (AE165), hence it affected student grades in more than one course; (b) the project carries a greater weight towards the course grade (20% vs. 5% for each of the rest OEPs); (c) a much higher level of engagement is achieved when students work on a problem of their choice.

It is also worth noting that 32% of the students found the course material difficult. The main reason for this perception is inadequate preparation in the course prerequisites (calculus, physics, and fluid mechanics). This fact is confirmed by student test scores on the Fluid Mechanics Concept Inventory, given to them at the beginning of the course. Students typically average 45-50% on this test. The deficiency with respect to Fluid Mechanics was addressed by replacing ME111 with AE160 in the BSAE curriculum, effective Fall 2010.

***Performance Criterion 3A-4.2: Define (open-ended) problems in appropriate engineering terms.***

***Assessment Summary:*** The performance target is met for Performance Criterion 3A-4.2.

***Assessment Tool***

Rubric for measuring student performance on Step 2 of the PSM

Score	Performance Criterion: Define one or more criteria (measures) for answering the question.
10	Identifies a proper “measure”. Includes appropriate sketches illustrating all relevant parameters.
7 - 9	Identifies a “measure” that can indirectly lead to a more appropriate one. Sketches illustrate some of the relevant parameters.
5 - 6	Identifies what may at first appear as a reasonable “measure” but which may later be shown to be inappropriate. Sketches illustrate some of the relevant parameters.
1 - 4	Does not specify a useful “measure” for the comparison. No sketches included.
0	Does not attempt.

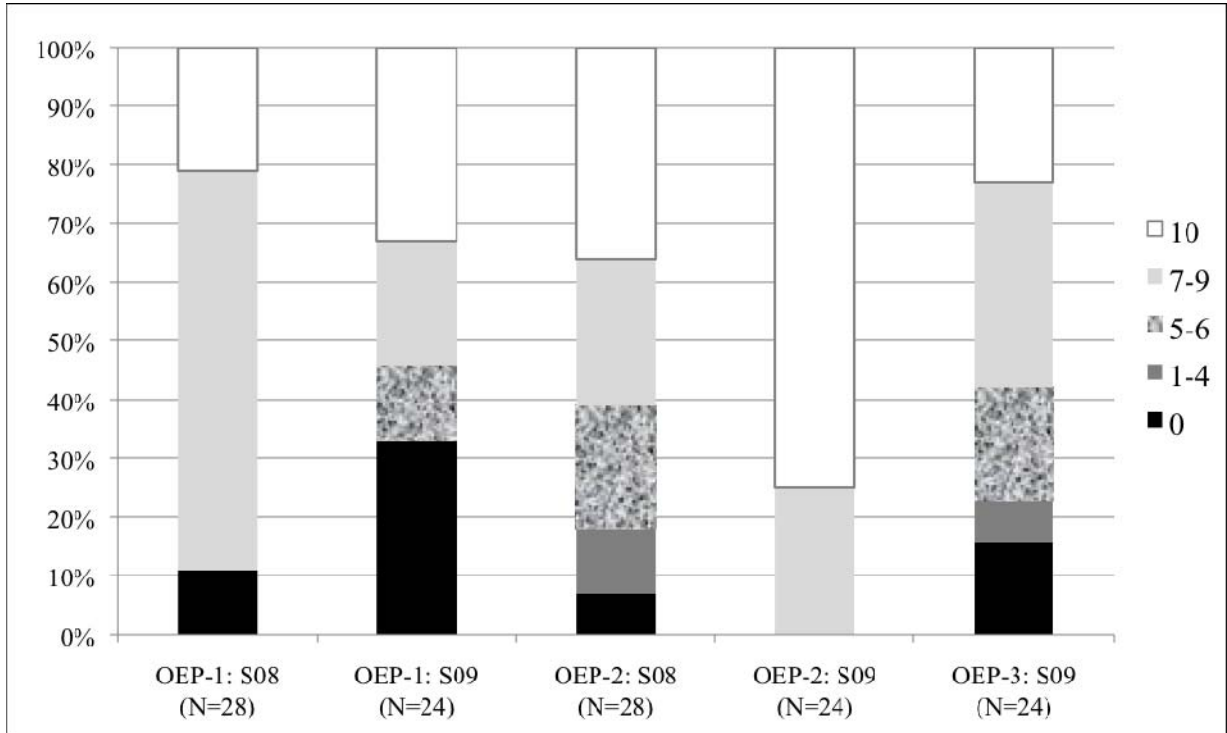


Figure 4.1 – Student performance on Step 2 of the PSM in AE162

**Analysis**

Figure 4.1 shows that in Spring 2008 students performed better in Step 2 in OEP-1 (89% scored 7 or higher vs. 61% for OEP-2). However, OEP-1 was team homework while OEP-2 was a final exam problem. In Spring 2009, 67% received passing scores in OEP-1 and 100% in OEP-2. In fact, all students scored 7 or higher in Step 2. Students also performed very well in the much more challenging OEP-3, although 25% did not receive a passing grade in Step 2. Forty one (41%) percent of the students in AE162 identified Step 2 as the greatest challenge in solving OEPs, expressing discomfort with the fact that so little information was given about each problem, unlike typical homework problems and exam questions.

**Performance Criterion 3A-4.3:** *Explore problems (i.e., examine various issues, make appropriate assumptions, etc.).*

**Assessment Summary**

The performance target is not met for Performance Criterion 3A-4.3.

**Assessment Tool**

Rubric for measuring student performance on Step 3 of the PSM

Score	Performance Criterion: Generate appropriate questions related to the “measures” you defined in Step 2, identify possible approaches (models) for solving the problem, and make reasonable assumptions.
10	Generates at least two relevant questions, identifies at least two different approaches, and makes all necessary assumptions for each approach.
7 - 9	Generates at least one relevant question, identifies at least two different approaches, and makes most of the necessary assumptions for each approach.
5 - 6	Generates at least one relevant question, identifies at least one approach, and makes most of the necessary assumptions for this approach.
1 - 4	Generates one or two relevant questions, does not identify an approach, does not make some or all of the necessary assumptions.
0	Does not attempt.

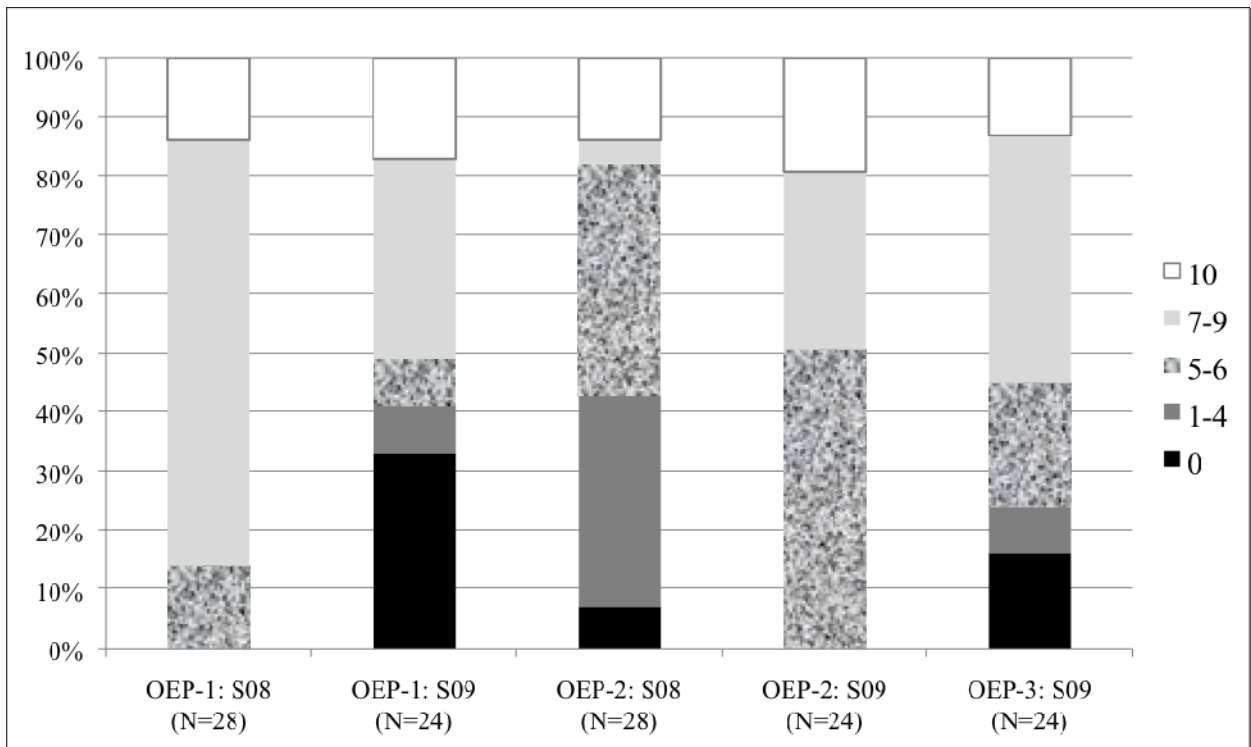


Figure 4.2 – Student performance on Step 3 of the PSM in AE162

**Analysis**

Figure 4.2 shows that student performance benefited from the team-effort in OEP-1 (Spring 2008) while 43% of the students did not perform adequately in this step in OEP-2 (individual effort, final exam). This trend, however, was reversed in Spring 2009 when 41% of the students did not receive a passing score in OEP-1 while all students performed adequately on OEP-2. As was the case with Step 2 students performed very well in the much more challenging OEP-3 although 24% did not receive a passing grade in Step 3.

Nine (9%) percent of the students identified Step 3 as the greatest challenge in solving OEP. An additional 18% identified Step 3 as the second greatest challenge in tackling OEP. By far the greatest difficulty expressed by students was making appropriate assumptions to simplify the problem. In their own words: “We didn’t know if our assumptions would lead to the right answer. We were trying to avoid making the problem too big (on one hand) versus oversimplifying it (on the other). Nevertheless students acknowledged that this ambiguity led to a better understanding of the material.

**Performance Criterion 3A-4.4:** *Develop a plan for the solution (i.e., select appropriate theories, principles, approaches).*

**Assessment Summary:** The performance target is met for Performance Criterion 3A-4.4.

**Assessment Tool**

Rubric for measuring student performance on Step 4 of the PSM

Score	Performance Criterion: Select an appropriate model for developing a solution, break down the problem into sub-problems, and determine what needs to be found in each sub-problem.
10	Selects the most appropriate model for developing a solution, breaks down the problem into appropriate sub-problems; provides complete list of what needs to be found in each sub-problem.
7 - 9	Selects an appropriate model for developing a solution, breaks down the problem into appropriate sub-problems; incomplete list of what needs to be found in each sub-problem.
5 - 6	Selected model for developing a solution is not described adequately; breakdown of problem into sub-problems is not appropriate or helpful; list of what needs to be found is incomplete.
1 - 4	Does not identify a model for developing a solution or does not break down the problem into sub-problems and / or does not list what needs to be found.
0	Does not attempt.

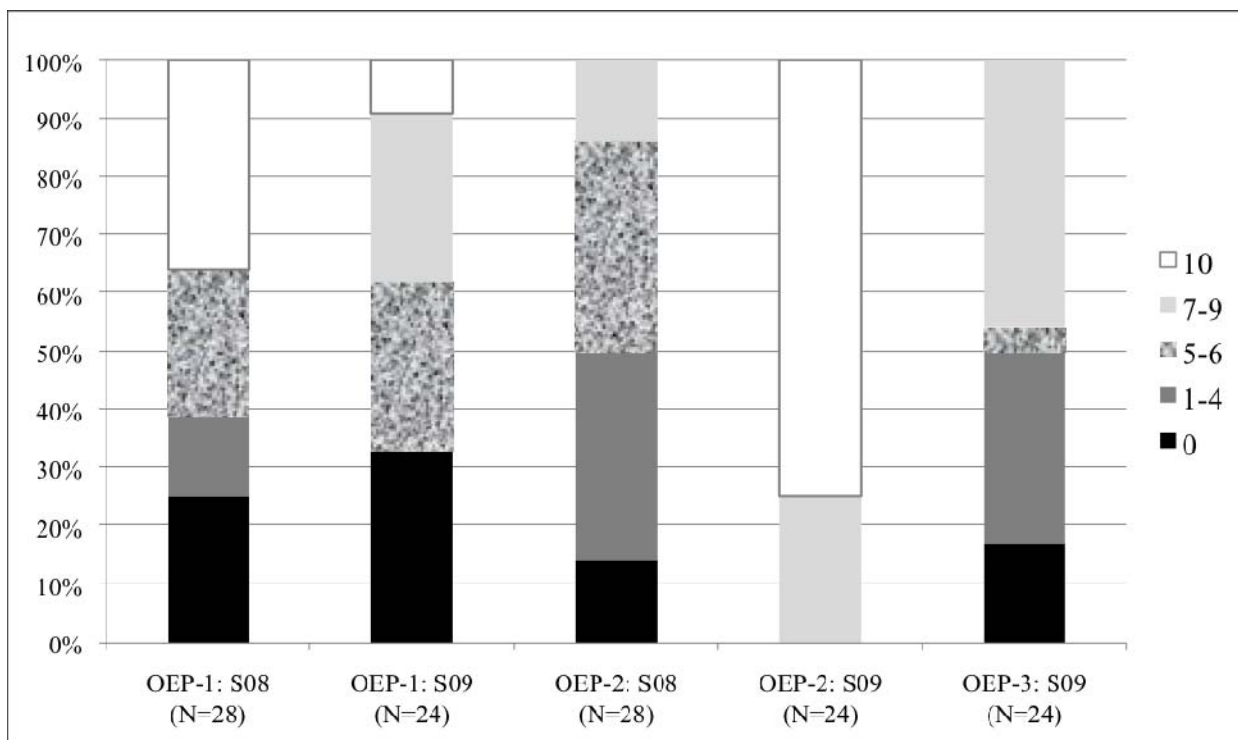


Figure 4.3 – Student performance on Step 4 of the PSM in AE162

**Analysis**

Figure 4.3 (Spring 2008) shows again that performance may improve when students work in teams. This trend is again reversed in Spring 2009 when students performed significantly better on OEP-2 on the final exam. However, a larger percentage of students (50%) performed poorly in Step 4 of OEP-3.

14% percent of the students in AE162 identified Step 4 as the greatest challenge in solving OEP. An additional 5% identified this step as the second greatest challenge in tackling OEP. Students find it difficult “figuring out which equations / principles to use”.

**Performance Criterion 3A-4.5:** *Implement their solution plan and check the accuracy of their calculations.*

**Assessment Summary:** The performance target is met for Performance Criterion 3A-4.5.

**Assessment Tool**

Rubric for measuring student performance on Step 5 of the PSM

Score	Performance Criterion: Substitute appropriate values of known and assumed quantities in the equations and carry out calculations correctly. Produce sketches, figures, and drawings as necessary.
10	All calculations are correct. Appropriate sketches, figures, and drawings included in the solution.
7 – 9	Most calculations are correct. Appropriate sketches, figures, and drawings included in the solution.
5 – 6	Some calculations are correct. Some sketches, figures, and drawings included in the solution.
1 – 4	Several of the calculations are incorrect. Important sketches, figures, and drawings are missing from the solution.
0	Does not attempt.

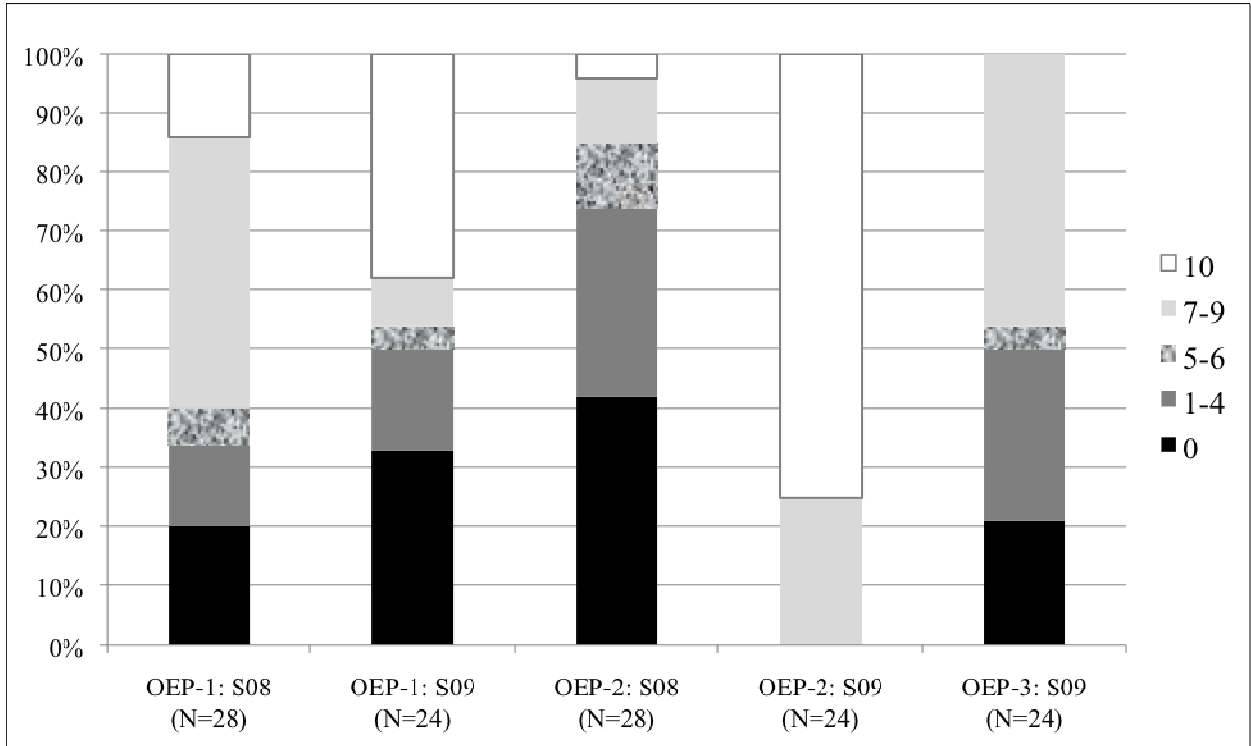


Figure 4.4 – Student performance on Step 5 of the PSM in AE162

***Analysis***

Figure 4.4 shows similar trends with Figure 4.3. This is to be expected, as student performance in Step 5 very much depends on their problem setup from Step 4. The large percentage of students (74%) who performed inadequately in Step 5 of OEP-2 (AE162, Spring 08) indicates again that many students were not ready to tackle an OEP on their own. Students did not identify any particular challenges in relation to Step 5.

**Performance Criterion 3A-4.6:** *Evaluate their results and reflect on their strengths and weaknesses in the process.*

***Assessment Summary***

The performance target is not met for Performance Criterion 3A-4.6.

**Assessment Tool**

**Rubric for measuring student performance on Step 7 of the PSM**

Score	Performance Criterion:
	Discuss whether answer makes sense, evaluate appropriateness of models used and any assumptions made. Reflect on personal problem solving process.
10	A. Comments on whether the answer is reasonable and why. Evaluates the appropriateness of any models used and any assumptions made. B. Reflects in depth on his/her personal problem solving process; identifies several strengths and several areas for improvement.
7 – 9	A. Comments on whether the answer is reasonable but does not explain why. Evaluates the appropriateness of any models used and some of the assumptions made. B. Reflects on the personal problem solving process. Identifies at least one strength and one area for improvement.
5 – 6	A. Comments on whether the answer is reasonable but does not explain why. Does not evaluate the appropriateness of any models used and/or some of the assumptions made. B. Inadequate reflection on the personal problem solving process. One strength and/or one area for improvement identified.
1 – 4	A. No comment on whether the answer is reasonable. No evaluation of the appropriateness of any models used and/or any assumptions made, based on the answer received. B. No reflection on the personal problem solving process. No strengths or areas for improvement identified.
0	Does not attempt.

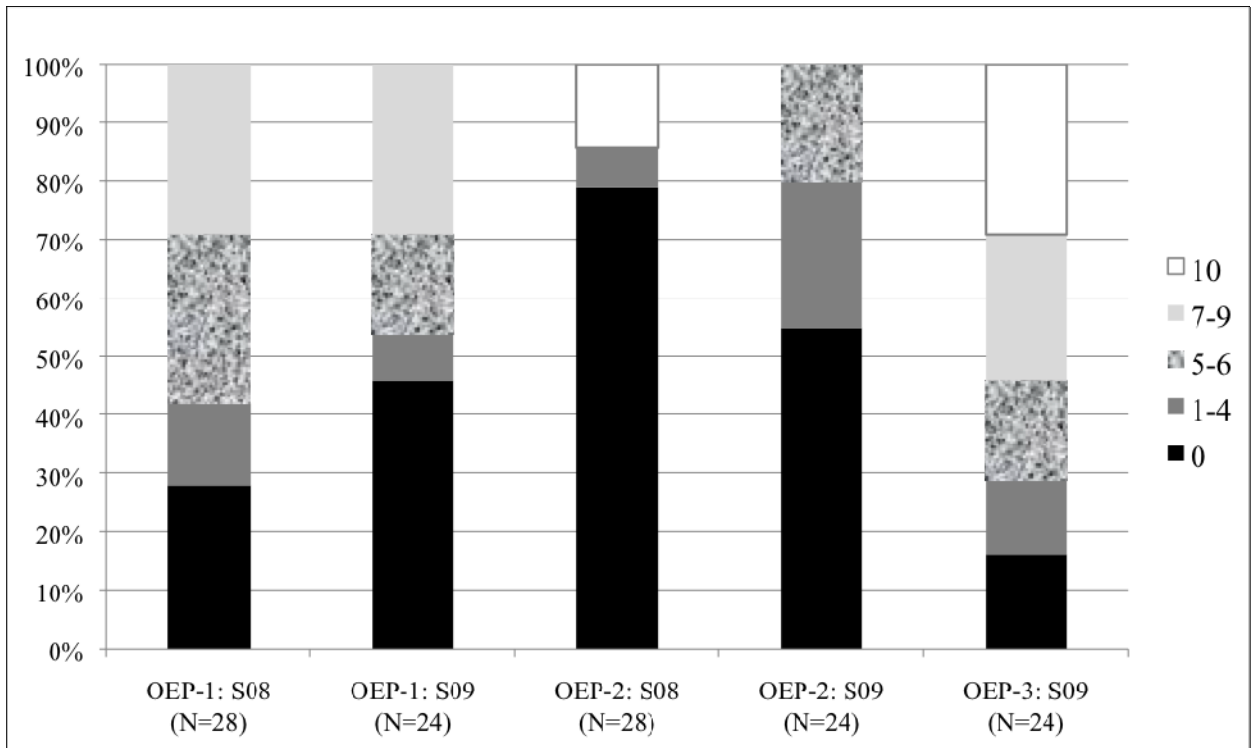


Figure 4.5 – Student performance on Step 7 of the PSM in AE162

Step 7 is critical for self-assessment and self-improvement. The large number of students who receive non-passing scores (0 – 4) confirms that students have great difficulty with

this final step. Nevertheless, very few students mentioned reflection as one of their major challenges.

Students included two separate reflections in their report for each problem. The first reflection involves the technical aspects of the problem and is performed by the team. The second reflection involves each member’s personal problem solving process and is carried out individually. As part of this personal reflection students were reminded to answer the following questions in their report for the last OEP in each class.

- (a) What was the greatest challenge you faced in solving OEP in this class?
- (b) What other difficulties did you experience in solving OEP?
- (c) What general skills did you learn (applicable to other classes / situations) from solving OEP in this class?
- (d) Do you have any specific suggestions for the instructor on how he can help students improve their problem solving skills?
- (e) Do you have any specific suggestions for students who try to solve OEP?

A qualitative analysis of student responses was conducted and the main conclusions are presented below.

Summary of student performance in the three OEP

	OEP-1	OEP-2	OEP-3
	Students Receiving Passing Grades in OEP with <i>min score</i> = 5		
Spring 2008	14/25 (56%)	5/25 (20%)	N/A
Spring 2009	14/24 (58%)	3/24 (13%)	17/24 (71%)
	Students Receiving Passing Grades in OEP with <i>min score</i> = 7		
Spring 2008	4/25 (16%)	0/25 (0%)	N/A
Spring 2009	13/24 (54%)	2/24 (8%)	12/24 (50%)

Transferable Skills

Students identified the following skills, acquired in the process of solving OEP, as transferable:

- The ability to use the PSM. They found the PSM to be “very effective”, as it gave them “a logical, systematic approach for solving problems”, “a scientific way of thinking”, and helped them to “be organized”. Furthermore, they stated that the PSM made it easier for them to “reflect on their mistakes or weaknesses in the problem solving process”.
- Confidence in solving real-world problems. This shows that it is possible to increase student confidence level with a systematic teaching of problem solving skills. “I can now look at real-world problems and apply basic principles to solve them”, said one student. Student confidence in their cognitive problem-solving skills is summarized in Table 8.
- Making reasonable assumptions.
- Team skills, such as ability to discuss a problem effectively and reach consensus.

## Student Difficulties in Solving OEP

It is important to distinguish between cognitive and affective difficulties in problem solving. The cognitive domain is concerned with intellectual outcomes, such as knowledge, understanding, and skills. The affective domain involves emotional outcomes, such as interests, attitudes, and values. Emotional outcomes are very important when considering some of the attributes needed for problem solving, such as, for example, willingness to risk and cope with ambiguity, welcoming change and managing stress.

Top cognitive difficulties as identified by students as well as by the course instructors:

- Applying first principles in the solution of problems.
- Integrating knowledge from the entire course / more than one course.
- Reflecting on the problem solving process.
- Self-assessment of their problem solving skills.
- Defining a problem in engineering terms.
- Selecting a valid model for a problem (making appropriate assumptions).
- Following the PSM in its entirety.

Top affective difficulties as identified by students as well as by the course instructors:

- Unwillingness to spend sufficient time on task.
- Reluctance to write down ideas and create sketches while solving a problem.
- Dealing with ambiguity and uncertainty (lack of confidence).
- Working effectively in teams (coordinating meetings outside of class, dysfunctional teams, and agreeing on an approach to solve each problem).

It is evident that no improvement in cognitive problem solving skills can take place unless students bring with them the right attitudes and values when approaching OEP. For example, one must stay flexible while brainstorming possible ways to model a physical situation (Step 3) and value accuracy more than speed while implementing a mathematical model (Step 5). Needless to say being organized and systematic is a requirement throughout the PSM. It is clear that with the exception of Step 1, which is entirely affective, the rest of the steps require a mix of affective and cognitive skills.

## Student Confidence in Problem Solving

A survey was distributed at the end of the semester, after completion of the last OEP, and included questions related to student confidence in their cognitive skills (Table 8) as well as student attitudes and habits during problem solving. The tables below summarize student responses.

**Student confidence in their cognitive problem solving skills (N=22)**

Indicate your level of confidence in each of the following:	I am very confident	I am somewhat confident	I am not at all confident
Following the PSM to solve OEP	18%	73%	9%
Following the PSM to solve well-defined problems (examples in the book, homework problems)	55%	45%	0
Monitor my problem solving process and reflect upon its effectiveness	37%	59%	4%
Draw upon my knowledge of the material when I solve practical, real world problems in new situations	41%	55%	4%
Use an approach that emphasizes fundamentals rather than trying to combine memorized sample solutions	50%	50%	0

**Student affective skills as they relate to problem solving (N=22)**

Indicate how often you do each of the following when you solve problems:	Never / Rarely	Sometimes	Very often / Always
I am more concerned about accuracy than speed	0	36%	64%
I sketch a lot, write down ideas, and create charts / figures to help me visualize the problem	9%	55%	36%
I am organized and systematic	14%	64%	22%
I stay flexible (I keep my options open, I can view a situation from different perspectives)	14%	45%	41%
I am willing to take risks (try new things even though I am not be sure about the outcome)	14%	41%	45%
I cope well with ambiguity, welcoming change and managing stress	9%	73%	18%

While grading the various OEP it became apparent that lack of affective skills was a primary cause for low performance. The most common reason for a low score was a sloppy report with incomplete steps, indicating inadequate time spent on the problem. For example, in many cases where students set up and solved an incorrect model for a problem, they had failed to include necessary sketches in steps 2, 3, and 4. As a result they did not visualize the problem correctly. On the other hand, students who performed well were usually meticulous about completing each step of the PSM (i.e. they took time to research and read, explored various possibilities before settling on an approach, sketched a lot in their effort to visualize the problem, and presented everything they did in a clear, organized, and systematic way).

***Recommendations***

Students were asked to make anonymously specific suggestions for the instructor on how he can help improve their problem solving skills. They were also asked to make specific suggestions for other students who try to solve OEP. The following is a summary of their recommendations:

Suggestions for the instructor:

- 32% of the students felt that there was no need to change the way OEP were introduced and problem solving skills taught. Students wrote that “the class is very

interesting”, “problems are explained clearly”, “the guidelines are very structured”, “examples are covered very thoroughly”, and “I like the way we did it!”.

- 32% of the students suggested more in-class examples of how to solve OEP.

Suggestions for other students:

- 14% of the students made suggestions related to time management: “Start working on each problem early; don’t try to do it all in one day!”, “give yourself time to study, understand, and visualize each problem”.
- 19% of the students urged fellow students to “follow the PSM and you will do just fine”. “It helps a great deal in seeing what you have and where you need to go”, one student said. “Think about the problem holistically, sketch and research before attempting any calculations”. Another suggested “first tackle problems in a way that makes sense to you, then follow the PSM to organize your ideas”.
- “Work with your team” and “find teammates you can work with” was a suggestion made by 15% of the students. “Don’t be afraid to argue with your teammates” but also “listen to your teammates and be open to their views”, wrote one student. “Different minds bring different ideas and knowledge to the table”, said another.
- “Talk to the instructor”, suggested 18% of the students. “Ask for as much help as possible”. On the balancing side a student urged to “try to solve the problem by yourself first, without talking to anyone. Ask for help only when you can’t figure out something”.
- “Keep an open mind and explore different approaches” was a suggestion made by 10% of the students.

**Implementation:** AY 2010 - 2011

**Outcome 3B – Ability to design and conduct water / wind tunnel experiments as well as to analyze and interpret data from such experiments.**

**Course Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 162	Spring 2008	Dr. Nikos J. Mourtos	28	22	79%
AE 160	Fall 2010	Dr. Nikos J. Mourtos	24	15	63%

**Course Design to Address Outcome 3B**

The laboratory experience in these courses 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 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.

Lab Report Grading Rubric<sup>1</sup>

	Total Score	112
1. Abstract		<b>10</b>
2. Experimental Design		<b>42</b>
• Practical importance of this experiment		4
• (1) Define goals and objectives		4
• (2a) Research / summarize relevant theory		10
• (2b) Research / summarize previous data		4
• (2c) Computer simulations (if available)		4
• (3) Select dependent and independent variables		4
• (4) Select appropriate methods to measure these variables		4
• (5) Select proper range for independent variables		4
• (6) Determine appropriate number of data points for each type of measurement.		4
3. Experimental results		<b>20</b>
4. Discussion		<b>20</b>
• Interpretation of results		
• Explanation of any discrepancies with theory and / or published data and / or computer simulations		
5. References		<b>10</b>
6. Appendices		<b>10</b>
• Raw data		
• Data Analysis - Calculations		
• Published data		
• Other		

**Course Activities (AE 160)**

- a. 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.
- b. 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.
- c. Design and perform a wind tunnel experiment to study the drag of an airfoil from wake measurements and analyze the results.
- d. 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)**

- a. 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).
- b. 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.

<sup>1</sup> < <http://www.engr.sjsu.edu/nikos/courses/Common/Labs/Lab.rubric.htm> >

- c. 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.
- d. 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).

**3B.1 – Ability to design water / wind tunnel experiments**

Outcome Element 3B.1 is assessed in the “design of experiment” section of each lab report and accounts for 40% of the grade for each experiment.

**Assessment Summary:** The performance target is met for Outcome Element 3B.1. 100% of the students met the performance target in all the performance criteria for Outcome Element 3B.1, in one experiment in AE160.

**Performance Criterion 3B-1.1:** *Define goals and objectives for the experiment.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.1.

**Assessment Tool**

Rubric for measuring student performance on Step 1 of the DoE process

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

**Student Performance Results**

	Students who scored “2” or higher on the rubric	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	22 / 22 (100%)	15 / 15 (100%)
Experiment 2	19 / 22 (86%)	15 / 15 (100%)
Experiment 3	14 / 22 (64%)	15 / 15 (100%)
Experiment 4	20 / 22 (91%)	15 / 15 (100%)

**Performance Criterion 3B-1.2:** *Research relevant theory and published data from similar experiments.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.2.

**Assessment Tool**

Rubric for measuring student performance on Step 2 of the DoE process

NOT PASS	0	No theory. Previously published data not included. No computer simulations.
	1	Theory section, 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.

**Student Performance Results**

	Students who scored “2” or higher on the rubric					
	AE 162 (Spring 08)			AE 160 (Fall 10)		
	Theory	Published Data	Computer Simulations	Theory	Published Data	Computer Simulations
Experiment 1	22 / 22 (100%)	18 / 22 (64%)	N/A	15 / 15 (100%)	15 / 15 (100%)	15 / 15 (100%)
Experiment 2	22 / 22 (100%)	15 / 22 (68%)	13 / 22 (59%)	15 / 15 (100%)	15 / 15 (100%)	15 / 15 (100%)
Experiment 3	15 / 22 (68%)	15 / 22 (68%)	22 / 22 (100%)	15 / 15 (100%)	13 / 15 (87%)	15 / 15 (100%)
Experiment 4	22 / 22 (100%)	18 / 22 (64%)	22 / 22 (100%)	15 / 15 (100%)	13 / 15 (87%)	N / A

**Performance Criterion 3B-1.3:** *Select the dependent and independent variables to be measured.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.3.

**Assessment Tool**

Rubric for measuring student performance on Step 3 of the DoE process

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 Identified range for one variable
	3	Identified dependent and independent variables and relationship between them Identified ranges for both
	4	Identified dependent and independent variables and relationship between them Identified ranges for both Identified appropriate increments for measurements

**Student Performance Results**

	Students who scored “2” or higher on the rubric	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	18 / 22 (82%)	11 / 15 (73%)
Experiment 2	14 / 22 (64%)	15 / 15 (100%)
Experiment 3	22 / 22 (100%)	13 / 15 (87%)
Experiment 4	10 / 22 (45%)	13 / 15 (87%)

**Performance Criterion 3B-1.4:** *Select appropriate methods for measuring / controlling each variable.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.4.

**Assessment Tool**

Rubric for measuring student performance on Step 4 of the DoE process

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

**Student Performance Results**

	Students who scored “2” or higher on the rubric	
	AE162 (Spring 08)	AE160 (Fall 10)
Experiment 1	18 / 22 (82%)	11 / 15 (73%)
Experiment 2	18 / 22 (82%)	15 / 15 (100%)
Experiment 3	14 / 22 (64%)	13 / 15 (87%)
Experiment 4	7 / 22 (32%)	13 / 15 (87%)

**Performance Criterion 3B-1.5:** *Select a proper range for the independent variables.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.5.

**Assessment Tool**

Rubric for measuring student performance on Step 5 of the DoE process

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.

***Student Performance Results***

	Students who scored “2” or higher on the rubric	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	18 / 22 (82%)	10 / 15 (67%)
Experiment 2	22 / 22 (100%)	15 / 15 (100%)
Experiment 3	22 / 22 (100%)	13 / 15 (87%)
Experiment 4	15 / 22 (68%)	13 / 15 (87%)

**Performance Criterion 3B-1.6:** *Determine an appropriate number of data points for each type of measurement.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B-1.6.

***Assessment Tool***

Rubric for measuring student performance on Step 6 of the DoE process

NOT PASS	0	Number of data points not identified
PASS	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.

***Student Performance Results***

	Students who scored “2” or higher on the rubric	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	22 / 22 (100%)	11 / 15 (73%)
Experiment 2	22 / 22 (100%)	13 / 15 (87%)
Experiment 3	22 / 22 (100%)	15 / 15 (100%)
Experiment 4	15 / 22 (68%)	13 / 15 (87%)

***Analysis***

- Overall, student ability to design experiments improved significantly from Spring 2008 to Fall 2010, as indicated by the improved scores in AE160 shown in the student performance results tables above. This is the result of spending considerably more time in class as well as in the lab coaching students on the skills pertaining to Outcome Element 3B.1.
- The lowest scores in AE162 were in the last experiment. This may be explained by the fact that this experiment was performed rather late in the semester and students

did not have as much time to prepare their lab reports. As a result, some teams submitted incomplete reports. This problem has now been addressed in two ways:

- The schedule for the four experiments has been adjusted, so students have more time to write their last lab report.
- Students must average at least 70% in their lab reports to earn a passing grade in each course (AE160 and AE162), regardless of their performance on exams and other assignments.
- The lowest scores in AE160 were in the first experiment. This may be explained by the fact that students were in the process of calibrating their efforts with the new standards and expectations presented to them in a new course.

**Recommendation:** None.

### ***3B.2 – Ability to conduct water tunnel / wind tunnel experiments***

**Assessment Summary:** The performance target is met for Outcome Element 3B.2.

**Performance Criterion 3B.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.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B.2.

#### ***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.

### ***3B.3 – Ability to analyze data from water / wind tunnel experiments***

**Assessment Summary:** The performance target is met for Outcome Element 3B.3.

**Assessment Tool**

Outcome Element 3B.3 is assessed in the results section of each lab report and accounts for 20% of the grade for each experiment.

**Performance Criterion 3B.3:** *Given a set of experimental data, carry out the necessary calculations, tabulate and plot the results using appropriate choice of variables and software.*

**Assessment Summary:** The performance target is met for Performance Criterion 3B.3.

**Student Performance Results**

	Students who scored 70% or higher	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	15 / 22 (68%)	15 / 15 (100%)
Experiment 2	9 / 22 (41%)	15 / 15 (100%)
Experiment 3	12 / 22 (55%)	13 / 15 (87%)
Experiment 4	11 / 22 (50%)	11 / 15 (73%)

**Analysis**

A large percentage of students did not perform adequately in this area in Spring 2008. In many cases, students knew what they were supposed to do, however, they chose not to do it simply because it was time consuming (e.g. presenting theoretical predictions, published experimental data, computer simulation data, and their own experimental results all on one and the same graph, allowing a comparison for discussion purposes). The requirement to average 70% in their lab reports, imposed for the first time in AE160 in Fall 2010 made for a significant improvement in student performance in this area.

**Recommendation:** None.

**3B.4 – Ability to interpret data from water / wind tunnel experiments**

**Assessment Summary:** The performance target is met for Outcome Element 3B.4.

**Assessment Tool**

Outcome Element 3B.4 is assessed in the discussion section of each lab report and accounts for 20% of the grade for each experiment.

**Performance Criterion 3B-4.1:** *Given a set of results in tabular or graphical form, make observations and draw conclusions regarding the variation of the parameters involved.*

**Performance Criterion 3B-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***

	Students who scored 70% or higher	
	AE 162 (Spring 08)	AE 160 (Fall 10)
Experiment 1	18 / 22 (82%)	12 / 15 (80%)
Experiment 2	6 / 22 (27%)	15 / 15 (100%)
Experiment 3	9 / 22 (41%)	15 / 15 (100%)
Experiment 4	12 / 22 (55%)	11 / 15 (73%)

***Analysis***

A large percentage of students did not perform adequately in this area in Spring 2008. In general, students are capable of making observations and drawing conclusions regarding the variation of parameters, however, they have difficulties explaining discrepancies between theory and experiment, experiment and published data or experiment and computer simulations. The requirement to average 70% in their lab reports, imposed for the first time in AE160 in Fall 2010 made for a significant improvement in student performance in this area, however, students still need help in this area.

***Recommendation***

Dedicate more class time to discuss reasons why experimental results may differ from theoretical predictions, previously published data or computer simulations.

***Implementation:*** AY 2011-2012

**Outcome 3C – 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**

**Courses Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 171A&B	Fall '06 / Spring '07	Dr. Nikos J. Mourtos	15	15	100%
AE 171A&B	Fall '08 / Spring '09	Dr. Nikos J. Mourtos	16	15	94%

**Performance Criterion 3C-1:** *Research, evaluate, and compare vehicles designed for similar missions.*

**Assessment Summary:** The performance target is met for Performance Criterion 3C-1.

**Course Activities (AE 171 A)**

Students present a comparative study of airplanes with a mission similar to theirs. The objective is to become familiar with the competition and work done by others. They use "Jane's All the World Aircraft" and the internet to collect data on various airplanes. Students compare and discuss important design parameters for the airplanes selected, such as takeoff and payload weight, available thrust, cruise speed and altitude, range, wing area, wingspan, wing aspect ratio, fuselage length, type of payload, etc.

**Assessment Tool**

Section 3 of Design Report 1 – Mission specification and comparative study

**Student Performance Results**

	Students who scored 70% or higher
AE 171 A – Fall 2006	15 (100%)
AE 171 A – Fall 2008	15 (100%)

**Analysis**

Students typically do very well on this assignment; no improvements are needed.

**Recommendation:** None

**Performance Criterion 3C-2:** *Follow a prescribed process to develop the conceptual / preliminary design of an aerospace vehicle.*

**Assessment Summary:** The performance target is met for Performance Criterion 3C-2.

**Course Activities (AE 171A&B)**

Students follow an iterative process (Roskam, 1985) to design their airplanes. This process involves mission specification, configuration selection, weight sizing, performance sizing, fuselage design, wing design, empennage design, landing gear design, weight and balance, stability and control analysis, drag polar estimation, and final

specification. The open-ended nature of design requires students to iterate through their design process in order to meet their mission requirements.

**Assessment Tool**

3 individual oral exams (two in AE171A, one in AE171B) during design briefings.

**Student Performance Results**

	Students who scored 70% or higher		
	1 <sup>st</sup> Exam (F06)	2 <sup>nd</sup> Exam (F06)	3 <sup>rd</sup> Exam (S07)
AE171A&B – F06/S07	7 (47%)	2 (13%)	10 (67%)
AE171A&B – F08/S09	9 (60%)	14 (93%)	15 (100%)

**Analysis**

Student performance was poor in AY 06-07, especially in the first semester, despite the fact that student teams produced reasonably good designs. The reason for this is that when students work in teams they do not always take the time to learn from each other all the parts of the design process. Rather, they tend to specialize in particular areas of the design, for which they take responsibility. To ensure that all students are adequately knowledgeable in the entire design process, students are tested individually during each of their design briefings in class. As the data for AY 06-07 show, this process alone did not produce satisfactory results. To help students prepare for these oral exams, design questions<sup>2</sup> have been posted on the course website. The answers to these questions are discussed in class and many (not all) are also found in the textbook. Additional references are also given for each question. Students are responsible for researching the answers to these questions in their textbook as well as in other sources to prepare for their oral exams. This approach improved student performance significantly in AY 08-09. As a result, all students met the performance target during the third oral exam in Spring 2009.

**Recommendation**

Post answers to the design questions on the course website for easy reference.

**Implementation:** AY 2011-2012

**Performance Criterion 3C-3:** *Develop economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints and design a vehicle that meets these constraints.*

**Assessment Summary:** The performance target is met for Performance Criterion 3C-3.

**Course Activities** (AE 171A&B)

- Develop economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints as appropriate for their airplane.
- Take into consideration these constraints in the design of their airplane and discuss how well their particular design meets these constraints.

**Assessment Tools:** Design Report 1, Section 2 and Design Report 12.

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<sup>2</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/design.questions.htm> >

***Student Performance Results***

	Students who scored 70% or higher	
	Design Report 1, Section 2.3	Design Report 12
AE170A&B.1 – F06/S07	15 (100%)	15 (100%)
AE171A&B – F08/S09	16 (100%)	15 (100%)

***Analysis***

Student performance is generally good in this area. Sometimes students need help identifying realistic constraints, especially for airplanes designed for the SAE Aero-Design or the AIAA Design-Build-Fly competitions. Students may also need help analyzing how well their airplane meets certain constraints. Nevertheless, they seem to grasp the importance of specific constraints in airplane design and do a fairly good job meeting those constraints in their designs. Their assignments for outcomes 3F and 3G (see discussion below) are particularly helpful in this area, as they broaden their horizons beyond the technical aspects of airplane design. As a result of these assignments students have a much better understanding of how to deal with their specific constraints.

***Recommendation:*** None

**Performance Criterion 3C-4:** *Select an appropriate configuration for an aerospace vehicle with a specified mission.*

***Assessment Summary:*** The performance target is met for Performance Criterion 3C-4.

***Course Activities*** (AE171A)

- Study the configurations of aircraft with a mission specification similar to the proposed airplane; discuss the reasons for the selection of the particular configuration in each of these aircraft.
- Select and sketch a few overall configurations for the proposed airplane; discuss the pros and cons of each configuration. Select one of these configurations for preliminary design purposes and justify the choice.
- Select the specific wing, empennage, landing gear, and propulsion system configuration, discuss the pros and cons of each configuration and justify the choice.

***Assessment Tool:*** Design Report 2 – Configuration Design

***Student Performance Results***

	Students who scored 70% or higher
AE 171 A – Fall 2006	15 (100%)
AE 171 A – Fall 2008	15 (100%)

***Analysis***

Students typically do very well on this assignment; no improvements are needed.

***Recommendation:*** None

**Performance Criterion 3C-5:** *Apply AE principles (ex. aerodynamics, structures, flight mechanics, propulsion, stability and control) to design various vehicle subsystems.*

**Assessment Summary:** The performance target is met for Performance Criterion 3C-5.

**Course Activities (AE171A&B)**

Students apply AE principles throughout their conceptual and preliminary design of their airplane.

**Assessment Tools**

The following design reports<sup>3</sup>: weight sizing (Report 3, AE171A), performance sizing (Report 4, AE171A), fuselage design (Report 5, AE171A), wing, high-lift system, and lateral controls design (Report 6, AE171A), empennage, longitudinal and directional controls design (Report 7, AE171A), landing gear design (Report 8, AE171A), weight and balance analysis (Report 9, AE171B), stability and control analysis (Report 10, AE171B), and drag polar estimation (Report 11, AE171B).

**Student Performance Results**

	Students who performed at 70% or higher								
	Rep.3	Rep.4	Rep.5	Rep.6	Rep.7	Rep.8	Rep.9	Rep.10	Rep.11
AY 06-07	100%	100%	100%	100%	100%	100%	100%	100%	67%
AY 08-09	100%	100%	100%	100%	100%	100%	100%	100%	100%

**Analysis**

This Criterion is very broad. Student performance in the various reports varies from team to team and from year to year. It is not uncommon for a team to receive a low score or even a No-Credit in one of their reports. When this happens, I meet with the students and discuss areas for improvement. Students correct and re-submit their reports within two weeks. This explains how the performance criterion is met in Reports 3 through 11. In AY 06-07 one team did not re-submit their corrected Report 11 following my discussion with them.

**Recommendation:** None

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<sup>3</sup> The specific content for each report is described at <<http://www.engr.sjsu.edu/nikos/courses/ae171/project.htm>>

**Outcome 3D – Ability to collaborate with people from different cultures, abilities, backgrounds, and disciplines to complete AE projects**

**Assessment Summary:** The performance target is met for Outcome 3D.

**Courses Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 171A&B	Fall '07 / Spring '08	Dr. Nikos J. Mourtos	11 (2 teams)	11	100%
AE 171A&B	Fall '10 / Spring '11	Dr. Nikos J. Mourtos	12 (2 teams)	12	94%

**Course Activities (AE171A&B)**

- Engage in team building activities.
- Present and discuss the “17 laws of teamwork” (Maxwell, 2001).
- Work in teams (typically 4–6 students) to design an aircraft. For some projects students also work in teams to build and test fly their aircraft. The multicultural aspect of teamwork is inherent in all teams in our capstone, senior design experience, simply by virtue of our multicultural student population<sup>4</sup>. Nevertheless, an additional effort is made to create teams that are as diverse as possible in terms of cultural background as well as abilities.
- Individuals and teams are coached throughout the year on how to improve their team skills.
- Evaluate the performance of teammates at the end of each semester based on 7 specific criteria. Peer reviews are taken into consideration when individual grades are assigned.

**Performance Criterion 3D-1:** *Committed to the team and the project, dependable, faithful, reliable. Attends all meetings; arrives on time or early. Comes to the meetings prepared and ready to work.*

**Performance Criterion 3D-2:** *Leadership: takes initiative, makes suggestions, provides focus. Creative, brings energy and excitement to the team. Has a “can do” attitude. Sparks creativity in others.*

**Performance Criterion 3D-3:** *Gladly accepts responsibility for work and gets it done; spirit of excellence.*

**Performance Criterion 3D-4:** *Has abilities the team needs. Makes the most of these abilities. Gives fully, doesn’t hold back.*

**Performance Criterion 3D-5:** *Communicates clearly when speaking and writing. Understands the direction of the team.*

**Performance Criterion 3D-6:** *Personality: positive attitudes, encourages others, seeks consensus, brings out the best in others.*

**Assessment Summary:** The performance target is met for all the Performance Criteria.

<sup>4</sup> For example, an aircraft design team in a recent year included members with cultural backgrounds from Singapore, El Salvador, Philippines, Mexico, and Tibet.

**Assessment Tool**

Students use the following rubric to evaluate the performance of their teammates as well as their own at the end of each semester.

**Team Member Report Card**

Project Title:					
	Criteria	Filled out by:			
		Member 2	Member 3	Member 4	Self
1	<i>Quality of Technical Work:</i> Work is correct, clear, complete, and relevant to the problem. Equations, graphs, and notes are clear and intelligible.				
2	<i>Commitment to Team / Project:</i> Attends all meetings. Arrives on time or early. Prepared. Ready to work. Dependable. faithful. reliable.				
3	<i>Leadership:</i> Takes initiative, makes suggestions, provides focus. Creative. Brings energy and excitement to the team. Has a “can do” attitude. Sparks creativity in others.				
4	<i>Responsibility:</i> Gladly accepts work and gets it done. Spirit of excellence.				
5	Has abilities the team needs. Makes the most of these abilities. Gives fully. doesn’t hold back.				
6	<i>Communication:</i> Communicates clearly when he/she speaks and when she/he writes. Understands the team’s direction.				
7	<i>Personality:</i> Positive attitude, encourages others, seeks consensus. Brings out the best in others.				
	<i>Average score</i>				
Grading scale:					
5 – Always, 4 – Most of the time, 3 – Sometimes, 2 – Rarely, 1 – Never					
Keep in mind that if you award high scores to everyone, regardless of their contribution, team members who have worked unduly hard or provided extraordinary leadership will go unrecognized, as will those at the other end of the scale who need your corrective feedback.					
Please write below and on the back of this form one ( <b>minimum</b> ) or more paragraphs about the work of <b>each member</b> of your team, including your own. These narratives should amplify the ratings you gave in the table, by (a) identifying the strengths and weaknesses of each individual and (b) suggesting ways in which his / her work can be more effective. Also, evaluate the team as a whole. Feel free to attach additional pages.					

**Student Performance Results for 3D-1, 3D-3, 3D-4, 3D-5, 3D-6**

	% of students who averaged 4 (most of the time) or higher on Item 2	
AY 07-08	10 (91%)	10 (91%)
AY 10-11	12 (100%)	12 (100%)

**Analysis**

In AY 07-08 one student averaged lower than 4 on all Items of the rubric in both semesters. His teammates commented that he did not attend all the team meetings and when he did, he was not always prepared. His course grade was reduced as a result of his peer evaluations, however, his overall performance in the course allowed him to pass.

In AY 10-11 all students received peer review scores of 4 or higher on all items of the rubric, both semesters.

***Student Performance Results for 3D-2***

	% of students who averaged 4 (most of the time) or higher on Item 3	
AY 07-08	5 (45%)	7 (64%)
AY 10-11	12 (100%)	12 (100%)

***Analysis***

I believe that leadership is critical for the success of any team, hence I am presenting a separate summary for the results and analysis of this performance criterion. As the table above indicates, approximately half of the students received scores below 4 on leadership in AY 07-08. On the other hand, all students received scores 4 or higher in AY 10-11. The latter is more an indication that the teams worked well rather than proof that all students demonstrated leadership.

***Recommendation***

To help each and every student develop leadership skills, I will randomly appoint the team leaders for each team at the beginning of the semester and rotate leadership in all teams periodically, so all students will have an opportunity to practice and develop leadership skills. I will give team leaders specific tasks, will meet with them weekly, support them as best as I can, and hold them accountable to perform these tasks.

***Implement:*** AY 2011-2012

**Outcome 3E – Ability to communicate effectively through technical reports, memos, and oral presentations as well as in small group settings**

**Courses Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 171 A	Fall 2007	Dr. Nikos J. Mourtos	10	10	100%
AE 162	Spring 2008	Dr. Nikos J. Mourtos	28	22	79%
AE 171 B	Spring 2008	Dr. Nikos J. Mourtos	09	09	100%
Engr100W	Fall 2008	Dr. Thalia Anagnos	248	208	84%
AE 160	Fall 2010	Dr. Nikos J. Mourtos	24	15	63%
AE 171 A	Fall 2010	Dr. Nikos J. Mourtos	12	12	100%
AE 171 B	Spring 2011	Dr. Nikos J. Mourtos	11	11	100%

**Assessment Summary:** The performance target is met for Outcome 3E.

**Performance Criterion 3E-1.1:** *Produce well-organized reports, following guidelines.*

**Performance Criterion 3E-1.2:** *Use appropriate graphs and tables following published engineering standards to present results.*

**Courses Assessed:** AE160, AE162, AE171A&B

**Assessment Summary**

The performance target is met for Performance Criteria 3E-1.1 and 3E-1.2.

**Course Activities (AE 160, AE 162)**

Students produce four (4) extensive lab reports in each of the two courses, following specific guidelines<sup>5</sup>. In each report they present the design of their experiment, their results, and their discussion (interpretation) of the results.

**Course Activities (AE 171A&B)**

- Students produce a total of 12 design reports in AE171A&B<sup>6</sup>, one for each step of the preliminary design process. They follow general<sup>7</sup> and specific guidelines for the content and organization of each report (e.g. guidelines for Design Report 1<sup>8</sup>).
- Students participate in student design competitions and/or student conferences, where they present their projects. For these projects, design reports and/or conference papers are evaluated by engineers from industry and/or faculty from other universities, providing thus an additional measure of the quality of their writing.

<sup>5</sup> <<http://www.engr.sjsu.edu/nikos/courses/Common/Labs/Lab.Report.htm>>

<sup>6</sup> <<http://www.engr.sjsu.edu/nikos/courses/ae171/project.htm>>

<sup>7</sup> <<http://www.engr.sjsu.edu/nikos/courses/ae171/guidelines.htm>>

<sup>8</sup> <<http://www.engr.sjsu.edu/nikos/courses/ae171/pro-ms.htm>>

**Assessment Tool** (AE160, AE162)  
**Lab Report Grading Rubric**<sup>9</sup>

	Total Score	112
1. Abstract		10
2. Experimental Design		42
• Practical importance of this experiment		4
• (1) Define goals and objectives		4
• (2a) Research / summarize relevant theory		10
• (2b) Research / summarize previous data		4
• (2c) Computer simulations (if available)		4
• (3) Select dependent and independent variables		4
• (4) Select appropriate methods to measure these variables		4
• (5) Select proper range for independent variables		4
• (6) Determine appropriate number of data points for each type of measurement.		4
3. Experimental results		20
4. Discussion		20
• Interpretation of results		
• Explanation of any discrepancies with theory and / or published data and / or computer simulations		
5. References		10
6. Appendices		10
• Raw data		
• Data Analysis - Calculations		
• Published data		
• Other		

**Student Performance Results**

	Students who scored 70% or higher
AE160 – Fall 2010	15 (100%)
AE162 – Spring 2008	22 (100%)
AE171A&B – AY 08-09	10 & 9 (100%)
AE171A&B – AY 10-11	12 & 11 (100%)

**Analysis**

AE160/AE162: Lab reports that do not follow the posted guidelines are returned to students ungraded. Hence, all students follow the guidelines.

AE171A&B: Design reports that do not follow the posted guidelines are returned to students ungraded. Hence, all students follow the guidelines and perform well in these criteria. A sample of student participation in student and professional conferences is included below:

- 2011 **Page 7**, AIAA Design Build Fly Competition. Design report received a score of 90/100, placing them in 13<sup>th</sup> place out of 82 participating universities from the US and around the world.
- 2010 **Design of a Very Large Luxury Airship**<sup>10</sup>, 3<sup>rd</sup> Place-Team, AIAA Region VI Student Conference.
- 2009 **Design of a Micro-Scale Deployable Unmanned Aerial Vehicle**, 3<sup>rd</sup> Place-Team, AIAA Region VI Student Conference, also in Proc., Aerospace Engineering Systems Workshop, WSEAS<sup>11</sup>.

<sup>9</sup> < <http://www.engr.sjsu.edu/nikos/courses/Common/Labs/Lab.rubric.htm>>

<sup>10</sup> < <http://www.engr.sjsu.edu/nikos/pdf/VLLAirship%20AIAA.10.pdf>>

<sup>11</sup> < <http://www.engr.sjsu.edu/nikos/pdf/micro%20UAV.pdf>>

- 2009 *Design of a Skydiving Glider*, □Proc., Aerospace Engineering Systems Workshop, WSEAS<sup>12</sup>.
- 2008 *Spartan Phoenix Fire Surveillance Unmanned Aerial Vehicle*, 3<sup>rd</sup> Place-Team, AIAA Region VI Student Conference.
- 2008 □*Preliminary Design and CFD Analysis of a Fire Surveillance Unmanned Aerial Vehicle*, □Proc., Thermal-Fluids Analysis Workshop, TFAWS-08-1034<sup>13</sup>.
- 2008 *Double Wedge Shockwave Interaction Flow Characterization*, □Proc., Thermal-Fluids Analysis Workshop, TFAWS-08-1033<sup>14</sup>.
- 2007 *Design of a Heavy-Lift Remotely Controlled Aircraft*, SAE AutoDesk Inventor Award & 3<sup>rd</sup> Place-Team, AIAA Region VI Student Conference.
- 2007 *Design of a 3-Surface Aircraft for the Open-Class SAE Aero Design West Competition*, □Award of Excellence, SAE Aero Design West Competition.

**Recommendation:** None.

**Performance Criterion 3E-1.3:** *Use clear, correct language and terminology while describing experiments, projects or solutions to engineering problems.*

**Performance Criterion 3E-1.4:** *Describe accurately in a few paragraphs a project / experiment performed, the procedure used, and the most important results (abstracts, summaries).*

**Course Assessed:** Engr100W

#### **Assessment Summary**

The performance target is met for Performance Criteria 3E-1.3 and 3E-1.4.

#### **Statistics for Engr100W**

248 students enrolled, 30 of whom had a WST waiver, meaning they had taken the WST multiple times and never passed it. Students were granted a waiver by the AVP of Undergraduate Studies through a petition process. Students who enroll with a WST waiver are required to take Engr90W concurrently.

Student major distribution in Engr100W, Fall 2008

Major	# Students
Aerospace Engineering	7
Aviation	15
Chemical Engineering	8
Civil Engineering	50
Computer Engineering	27
Electrical Engineering	70
General Engineering	5
Industrial Engineering	2
Materials Engineering	8
Mechanical Engineering	31
Software Engineering	6
Technology	12
Open University	7
<b>Total Students</b>	<b>248</b>

<sup>12</sup> < <http://www.engr.sjsu.edu/nikos/pdf/skydive.pdf>>

<sup>13</sup> < <http://www.engr.sjsu.edu/nikos/pdf/TFAWS%2008-2.pdf>>

<sup>14</sup> < <http://www.engr.sjsu.edu/nikos/pdf/TFAWS%2008-1.pdf>>

### ***Assessment Tools***

*How to Interpret Exit Exam Scores:* The following description of Writing Skills Test (WST) scoring is taken from [www.sjsu.edu/larc/resources/wst/scoring/](http://www.sjsu.edu/larc/resources/wst/scoring/). The same scoring process and rubric is used for the Engr100W exit exam. The scoring rubric is on a scale of “0” to “6”. A “0” indicates that the student did not address the topic. The final score for the essay results from summing the scores of two reviewers.

A “6” essay demonstrates superior competence in writing on both rhetorical and syntactic levels. A “6” paper:

- is effectively organized and developed
- intelligently addresses the topic, showing maturity of thought and expression
- uses clearly appropriate details to support a thesis or illustrate ideas
- shows unity and consistent facility in use of language
- demonstrates a high level of syntactic variety and appropriate word choice
- is nearly free of error

A “5” essay demonstrates clear competence in writing on both the rhetorical and syntactic levels, though it may have occasional minor errors. A “5” paper:

- is generally well-organized and well-developed, though it may offer fewer details than a “6” paper
- may address some parts of the topic better than others
- shows unity, coherence, and progression
- demonstrates some syntactic variety and range of vocabulary
- displays facility in language

A “4” essay demonstrates competence in writing on both the rhetorical and syntactic levels. A “4” paper:

- is adequately organized
- addresses the topic adequately, though perhaps not complete
- uses some details to support a thesis or illustrate ideas
- demonstrates adequate but not distinguished facility with language and syntax
- may contain some errors that obscure meaning

A “3” essay, while it may demonstrate some developing competence in writing, remains flawed on either the rhetorical or syntactic level or both. A “3” paper may reveal one or more of the following weaknesses:

- inadequate development or organization
- failure to support or illustrate generalizations with appropriate or sufficient detail
- multiple errors in sentence structure and/or usage
- inappropriate choice of words or word forms

A “2” paper suggests limited competence in writing. A “2” paper may be seriously flawed by one or more of the following weaknesses:

- failure to organize or develop
- little detail or irrelevant specifics
- serious and frequent errors in usage and sentence structure

- problems with fluency and focus

A “1” paper demonstrates incompetence in writing. A “1” paper may reveal the writer's inability to comprehend the question, may be incoherent or impressively illogical. A paper that is severely underdeveloped falls into this category.

*How the WST Essay is Scored*

- Each essay is read twice, by two separate readers.
- After a score (anywhere from 6 to 1) is assigned, the essay is passed to another reader, who then reads it and assigns another score.
- If the readers are more than one number apart, i.e., a 4 and a 6, then the essay will be read a third time to determine the correct score.
- The scores must be only one number apart, i.e., a 6 and a 5. Those scores would give the essay a final score of 11.

***Student Performance Results***

Final course grades; of the 30 waiver students, only 16 passed the class

	Fall 2008	
Grade	# Students	Percent
A	95	38%
B	91	37%
C	22	9%
NC	36	15%
W	4	2%

Exit exam scores (N = 231); 17 students did not take the exam

	Fall 2008	
Exit Exam Score	# Students	Percent
12	0	0%
11	4	2%
10	24	10%
9	30	13%
8	90	39%
7	66	29%
6 (not pass)	17	7%

***Analysis***

93% of students who took the exam, passed it. Of those who passed the class the average change in score between the WST and the exit exam was  $\Delta WST = +0.78$ .

The following assumption was made in completing the analysis. For students who were granted waivers, the average of all WST essay scores was used as the initial score. For example, if a student took the WST 10 times, all 10 WST essay scores were averaged together to determine an initial score. In previous analyses a 4 was assigned to all students granted a waiver, but now we have access to better information through PeopleSoft. Previously, the change in score between the WST and the exit exam was reported as  $\Delta WST = \sim 1.0$ . The change in method for determining the initial score for waiver students accounts for the drop in average  $\Delta WST$  from  $\sim 1.0$  to 0.78.

Figure 1 plots Engr100W grades and exit exam scores. A linear trendline has been added to examine correlation but the fit is not very good ( $R^2=0.22$ ).

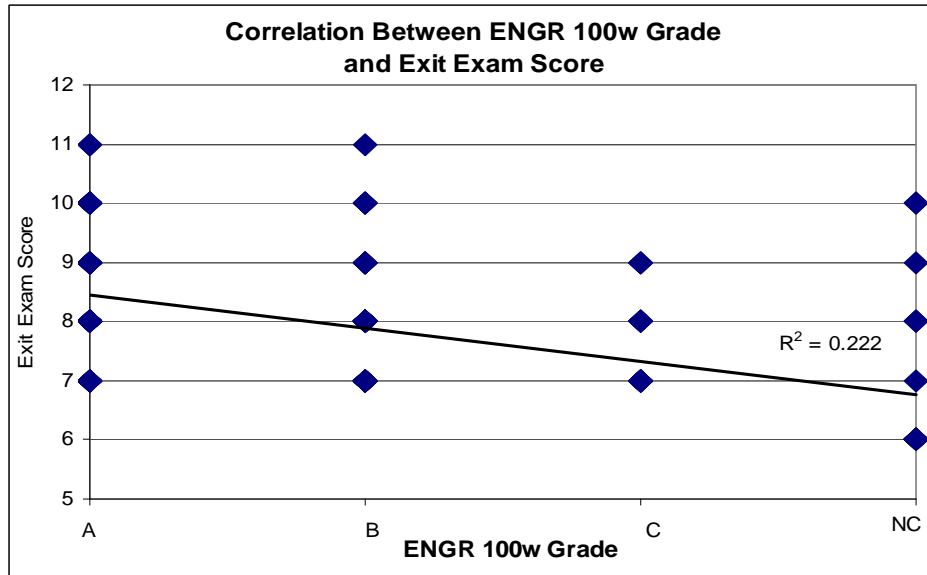


Figure 1 – Fall 2008 exit exam scores and Engr100W grades (n=231)

Figure 2 shows how the exit exam scores are distributed for each course grade. In general the A students score higher on the exit exam than C students. Sixty-two percent of C students earned 7s compared to 17% of A students. No C students earned 10 or 11. Of the students who earned an NC, only 19% passed the exit exam with a 7 or above. The remaining 81% earned a 6 or did not show up for the exam.

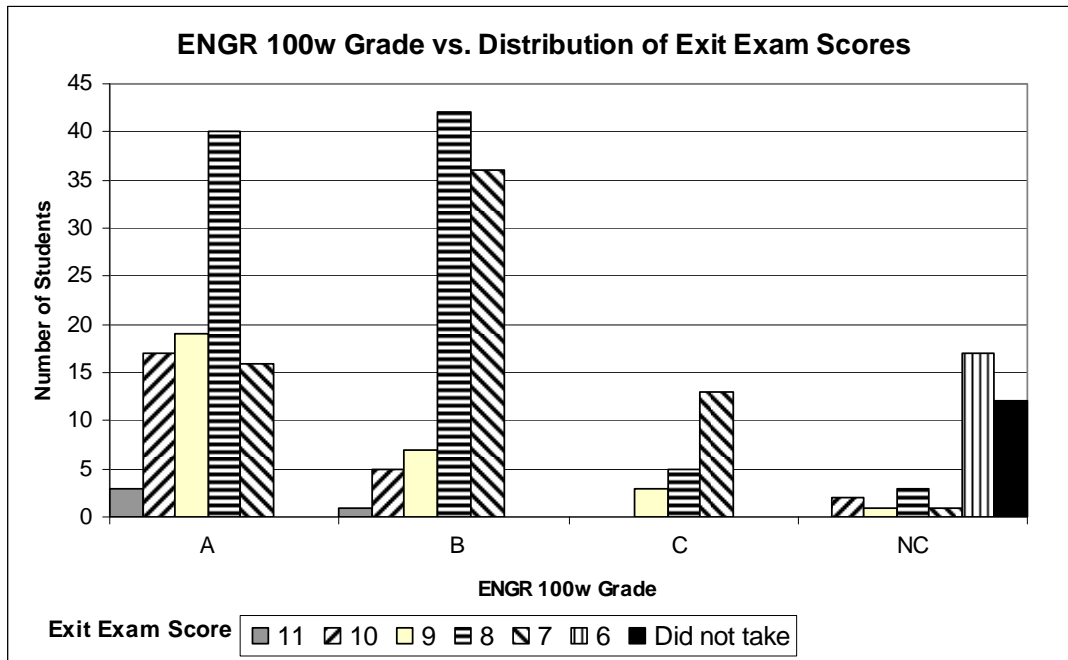


Figure 2 – Distribution of Fall 2008 exit exam scores compared with Engr100W grades

**Recommendation:** None.

- Performance Criterion 3E-2.1:** Give well-organized presentations, following guidelines.  
**Performance Criterion 3E-2.2:** Make effective use of visuals.  
**Performance Criterion 3E-2.3:** Present the most important information about a project / experiment, while staying within allotted time.

**Courses Assessed:** AE 171 A&B

**Assessment Summary**

The performance target is met for Performance Criteria 3E-2.1, 3E-2.2, and 3E2-3.

**Course Activities** (AE 171A & B)

- Students give 3 design briefings and a final presentation in the course of the year. All juniors, friends and relatives, and engineers from industry attend the final presentations at the end of the 2<sup>nd</sup> semester.
- Students may present their design project at the AIAA Student Conference, at the SAE Aero Design Competition, or at professional conferences (see above).

**Assessment Tool**

Rubric for Oral Presentation Evaluation

Project Title:

Student Names:

1. Technical Content: 10 (scale) x 6 = \_\_\_\_\_ / 60 points

Score	Performance Criterion
10	Included <b>all</b> pertinent technical info <b>AND</b> <b>all</b> equations, graphs, tables presented were correct.
7 – 9	Included <b>most</b> of the pertinent technical info (left out 1 or 2 pieces) + <b>all</b> of it was <b>correct</b> <b>OR</b> included <b>all</b> pertinent technical info + <b>most</b> of it was correct (a few errors).
5 – 6	Included <b>some</b> of the pertinent technical info (left out several important pieces) + <b>all</b> of it was correct <b>OR</b> included <b>all</b> pertinent technical info but only <b>some</b> of it was correct (several errors).
1 – 4	<b>Most</b> of the pertinent technical info was <b>missing</b> <b>OR</b> <b>most</b> of what was presented was <b>incorrect</b> .
0	<b>All</b> pertinent technical info was <b>missing</b> <b>OR</b> <b>everything</b> presented was <b>incorrect</b> .

Comments:

2. Organization: \_\_\_\_\_ / 10 points

Score	Performance Criterion
10	Presentation easy to follow (logical flow), appropriate emphasis on introduction, methodology, results and conclusions; good team member sequencing.
7 – 9	<b>One</b> of the following was true: (a) Presentation was not easy to follow OR (b) there was no introduction OR (c) methodology was unclear OR (d) results were unclear OR (e) conclusions were not clearly stated OR (f) rough team member sequencing.
5 – 6	<b>Two or three</b> of the following were true: (a) Presentation was not easy to follow, (b) there was no introduction, (c) methodology was unclear, (d) results were unclear, (e) conclusions were not clearly stated, (f) rough team member sequencing.
1 – 4	<b>Four or five</b> of the following were true: (a) Presentation was not easy to follow, (b) there was no introduction, (c) methodology was unclear, (d) results were unclear, (e) conclusions were not clearly stated, (f) rough team member sequencing.
0	<b>All</b> of the following were true: (a) Presentation was not easy to follow <b>AND</b> (b) there was no introduction <b>AND</b> (c) methodology was unclear <b>AND</b> (d) results were unclear <b>AND</b> (e) conclusions were not clearly stated <b>AND</b> (f) rough team member sequencing.

Comments:

3. Presentation Skills: \_\_\_\_\_ / 10 points

Score	Performance Criterion
10	Excellent briefing skills (ability to summarize key points in a few words), stayed within schedule, used visual aids appropriately, good eye contact with audience while speaking.
7 – 9	<b>One</b> of the following was true: (a) Briefing skills OK but not great OR (b) went overtime OR (c) used visual aids inappropriately OR (d) did not maintain eye contact with audience while speaking.
5 – 6	<b>Two</b> of the following were true: (a) Briefing skills OK but not great, (b) went overtime, (c) used visual aids inappropriately, (d) did not maintain eye contact with audience while speaking.
1 – 4	<b>Three</b> of the following were true: (a) Poor briefing skills, (b) went overtime, (c) used visual aids inappropriately, (d) did not maintain eye contact with audience while speaking.
0	<b>All</b> of the following were true: (a) Poor briefing skills AND (b) went overtime AND (c) used visual aids inappropriately AND (d) no eye contact with audience while speaking.

Comments:

4. Verbal Communication: \_\_\_\_\_ / 10 points

Score	Performance Criterion
10	Spoke clearly enough + slowly enough, used correct grammar + appropriate vocabulary.
7 – 9	<b>One</b> of the following was true: (a) Mumbled OR (b) spoke too fast OR (c) used incorrect grammar OR (d) used inappropriate vocabulary (ex. informations, aircrafts, vorticy, etc.)
5 – 6	<b>Two</b> of the following were true: (a) Mumbled, (b) spoke too fast, (c) used incorrect grammar, (d) used inappropriate vocabulary.
1 – 4	<b>Three</b> of the following were true: (a) Mumbled, (b) spoke too fast, (c) used incorrect grammar, (d) used inappropriate vocabulary.
0	<b>All</b> of the following were true: (a) Mumbled AND (b) spoke too fast AND (c) used incorrect grammar AND (d) used inappropriate vocabulary.

Comments:

5. Overall Impression: \_\_\_\_\_ / 10 points

Score	Performance Criterion
10	<b>Excellent</b> project quality, <b>excellent</b> presentation
7 – 9	<b>Excellent</b> project quality but <b>lacked</b> in presentation OR <b>very good</b> project quality, <b>excellent</b> presentation.
5 – 6	<b>Adequate</b> project quality, <b>good</b> presentation OR <b>good</b> project quality, <b>adequate</b> presentation.
1 – 4	Substandard project quality AND presentation.
0	Unacceptable project quality AND presentation.

Comments:

Total Score: \_\_\_\_\_ / 100 points

***Student Performance Results***

	Students who scored 70% or higher
AE171A&B – AY 07-08	10 & 9 (100%)
AE171A&B – AY 10-11	12 & 11 (100%)

***Analysis***

In general student presentations are very well organized. Students use visuals effectively and stay within the allotted time. The only area where students typically need improvement is in the presentation of the technical content (e.g. not all pertinent information is presented and/or some information presented is incorrect). However, any such errors are corrected by the time students participate at a conference or competition (AE171B), at which point they are usually very proficient in their presentation skills.

***Recommendation:*** None.

**Outcome 3F – Understanding of professional and ethical responsibility**

**Course Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE170A&B.Section 1	Fall 2005 / Spring 2006	Dr. Nikos J. Mourtos	17	11	100%
AE170A&B.Section 2	Fall 2005 / Spring 2006	Dr. Periklis P. Papadopoulos			
AE171A&B	Fall 2008 / Spring 2009	Dr. Nikos J. Mourtos	13	12	92%
AE172A&B	Fall 2008 / Spring 2009	Dr. Periklis P. Papadopoulos			

**Assessment Summary:** The performance target is met for Outcome 3F.

**Performance Criterion:** *Given a job-related scenario that requires a decision with ethical implications, students can identify any ethical issues raised by reference to professional codes of ethics (e.g. NSPE, ASME), identify possible courses of action, discuss the pros and cons of each course of action, decide what is the best course of action, and justify their decision<sup>15</sup>.*

**Course Activities** (AE 171A&B, AE172A&B)

- The content that pertains to this performance criterion is based on four (4) case studies in ethics, safety, and liability issues<sup>16</sup>:
  - The V-Tail Bonanza
  - The Crash of American Airlines Flight 191
  - Doomed from the Beginning: □The Solid Rocket Boosters for the Space Shuttle
  - Apollo 13 – A Mission that Failed
- Both aircraft and spacecraft design students participate jointly in the presentation and discussion of these case studies.
- Students study the background information on each of these cases and make a 15-minute presentation in class. Aircraft design teams present the aircraft related cases and spacecraft design teams present the spacecraft related cases. For the American Airlines Flight 191 case study a video is also shown in class, which presents a detailed analysis of the accident and its aftermath.
- Following the presentation of the background information on each case, students may (a) break into small groups for 20 min, discuss ethical issues raised, and summarize their position and arguments for each issue or (b) participate in a formal debate<sup>17</sup>.
- Each group presents a summary of their position orally as well as in writing and the floor is opened for additional comments by the rest of the class.

<sup>15</sup> Students also examine ethical constraints applicable to their particular vehicle design, as discussed in Outcome 3C

<sup>16</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/ethics.htm>>

<sup>17</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/ethicsbowl.htm>>

- Students follow up with a written paper in which they answer individually key ethical questions on each case.

***Assessment Tools***

- Presentation of the background of a case study.
- In class participation in group discussion and sharing.
- Individual written arguments in response to specific prompts in each of the four case studies.

***Student Performance Results***

	Students who scored 70% or higher			
	Case Study 1	Case Study 2	Case Study 3	Case Study 4
AE170A&B.1 – F05/S06	13 (76%)	17 (100%)	17 (100%)	17 (100%)
AE170A&B.2 – F05/S06				
AE171A&B – F08/S09	13 (100%)	13 (100%)	12 (100%)	12 (100%)
AE172A&B – F08/S09				

***Analysis***

Students are usually very engaged and perform well in their ethics assignments. Their arguments in class as well as in their individual papers indicate that they begin to appreciate the complexities of the ethical issues encountered in engineering design and in particular, in aerospace vehicle design. In AY 2005-2006 one aircraft design team and one spacecraft design team performed inadequately in their individual assignments on the first case study. However, their performance improved dramatically in the following three case studies.

***Recommendation***

Install “gateway” assignments related to this outcome, so that students must average at least 70% on their presentations, in-class participation, and papers, in each course, to earn a passing grade in the course, regardless of their performance on other aspects of the course.

***Implemented*** in AY 2010-2011<sup>18</sup>.

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<sup>18</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/grading.htm>>

**Outcome 3G – Broad education to understand current events, how they relate to AE, as well as the impact of AE solutions in a global and societal context**

**Course Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 171 B	Spring 2011	Dr. Nikos J. Mourtos	11	11	100%

**Assessment Summary:** The performance target is not met for Outcome 3G.

**Performance Criterion 3G-1:** *Identify regional, national, or global contemporary problems that involve AE.*

**Performance Criterion 3G-2:** *Discuss possible ways AE could contribute to the solution of these problems.*

**Performance Criterion 3G-3:** *Discuss the impact of AE in a global and societal context.*

**Course Activities (AE 171 B)**

- Assignment 1<sup>19</sup>: Each student identifies a **regional, national, or global contemporary problem** and discusses how aerospace engineering plays a role in it. For example, some of the topics selected in AE171B in AY 10-11 were:
  - Global war on terror with new aircraft design
  - No-fly zone over the Libyan airspace
  - Global hawk UAV and the earthquake in Japan
  - Aircraft and obesity
  - Jathropa biodiesel as an aviation fuel
  - Cloud seeding
- Students find at least 5 references that discuss their particular topic. At least two of these references must be technical journal articles or conference papers or technical reports. For the rest they may use newspapers, magazines, Aviation Week & Space Technology, and the worldwide web.
- Students study these references and prepare a two-page (minimum) paper summarizing the key points of their research and a 10 min PowerPoint presentation for our class. In their presentation they must include two key questions related to the issue (discussed in the article) to facilitate class discussion on the topic.
- Assignment 2<sup>20</sup>: Students find at least 5 references that discuss the **impact of aerospace vehicle design in a global / societal context**. At least two of these references must be technical journal articles or conference papers or technical reports. For the rest they may use newspapers, magazines, Aviation Week & Space Technology, and the worldwide web. For example, some of the topics selected in AE171B in AY 10-11 were:
  - Contribution of jet aircraft contrails to global warming
  - Environmental impact of aircraft disposal

<sup>19</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/Current.Events.htm>>

<sup>20</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/Global.Societal.htm>>

- Engine efficiency and its impact on the airplane DOC and the environment
- The effect of airplanes on cultural integration
- Aircraft design and urban development
- Setting the standards for flying cars
- Students study these references and prepare a two-page (minimum) paper summarizing the key points of their research and a 10 min PowerPoint presentation for our class. In their presentation they must include two key questions related to the issue (discussed in the article) to facilitate class discussion on the topic.

***Assessment Tools***

- In-class presentation of the regional, national or global contemporary problem.
- Written analysis of the problem based on identified references.
- In-class presentation of an example of the impact of aerospace vehicle design in a global / societal context.
- Written analysis of this example of the impact of aerospace vehicle design in a global / societal context based on identified references.

***Student Performance Results***

	Students who scored 70% or higher	
	Current Event as it relates to Aerospace Engineering	Impact of Aerospace Vehicle Design in a Global / Societal Context
AE171B – S11	13 (100%)	12 (100%)

***Analysis***

Students are usually very engaged and perform well in this area, however, these assignments have so far been implemented only in AE171B (Aircraft Design II).

***Recommendation***

Install “gateway” assignments in both AE172B related to this outcome, so that students must earn at least 70% on their presentations and papers, in each of these two assignments, to earn a passing grade in the course, regardless of their performance on other aspects of the course.

***Implemented*** in AY 2011-2012<sup>21</sup>.

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<sup>21</sup> < <http://www.engr.sjsu.edu/nikos/courses/ae171/grading.htm>>

**Outcome 3H – Recognition of the need for, and ability to engage in lifelong learning**

**Course Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 170 A&B Section 1	Fall 2006 / Spring 2007	Dr. Nikos J. Mourtos	15	15	100%
AE 162	Spring 2007	Dr. Nikos J. Mourtos	24	23	96%
AE 171 A&B	Fall 2009 / Spring 2010	Dr. Nikos J. Mourtos	09	09	100%
AE 162	Spring 2010	Dr. Nikos J. Mourtos	29	24	83%

**Assessment Summary:** The performance target is not met for Outcome 3H.

**Performance Criterion 3H-1:** *Develop a process for learning, reflect regularly on this process, identify personal strengths and weaknesses, and take the necessary steps to improve their learning process.*

**Assessment Summary:**

The performance target is not met for Performance Criterion 3H-1.

**Course Activities (AE162)**

Students reflect on their learning process during the semester, identify personal strengths and weaknesses, and develop strategies to improve their learning process.

**Assessment Tool:** Reflection journal

**Student Performance Results**

	Students who scored 70% or higher
AE162 – Spring 2007	15 (65%)
AE162 – Spring 2010	18 (75%)

**Analysis**

This performance criterion is similar to 3A-4.6. As discussed earlier in the context of problem solving skills, students initially have difficulty reflecting effectively on their learning process. In class, they are shown examples of proper reflections and they respond fairly well in terms of identifying their strengths and weaknesses. On the other hand, they are not always able to identify effective strategies for correcting these weaknesses and/or they do not always take the necessary steps to improve their learning process. This performance criterion has become more problematic over the years, as students devote less and less time studying for their courses and furthermore, they are not always capable of processing when they read in the text or other references.

**Recommendation**

Additional class time and effort must be devoted to guiding students in their reflections

and most importantly, to helping them develop and apply strategies for improving their learning process.

**Implementation:** AY 2011-2012

**Performance Criterion 3H-2:** *Access information effectively and efficiently from a variety of sources.*

**Performance Criterion 3H-3:** *Research and learn new material on their own by reading articles, books, contacting experts, etc.*

**Course Activities**

- AE162: In their course projects, students take responsibility to learn material not discussed in the lectures and demonstrate their knowledge of this material in their written and oral report at the end of the semester. Interaction with the instructor, as well as with other students is highly encouraged (not assessed).
- AE171A: Perform a comparative study of airplanes with similar mission. This assignment requires searching for appropriate references, studying these references, and summarizing the performance of several airplanes.
- AE171B: Students identify a regional, national, or global contemporary problem, find at least 5 references on this topic (two of which must be technical journal articles or conference papers or technical reports), summarize the key points and discuss how aerospace engineering plays a role in it.
- AE171B: Students find at least 5 references (two of which must be technical journal articles, conference papers or technical reports) that discuss the impact of aerospace vehicle design in a global / societal context and prepare a summary of the key points of their research.

**Assessment Tools**

AE171A: Report 1, Section 3

AE171B: Special assignment on current events

AE171B: Special assignment on the impact of aerospace vehicles in a global / societal context

**Student Performance Results**

	Students who scored 70% or higher		
	Report 1 – Section 3	Assignment on Current Events	Assignment on the Impact of Aircraft Design in a Global / Societal Context
AE170A&B.Section1 – Fall '06 / Spring '07	15 (100%)	15 (100%)	15 (100%)
AE171A&B – Fall '09 / Spring '10	09 (100%)	09 (100%)	09 (100%)

**Analysis**

Students access appropriate references from a variety of sources for each of these assignments and summarize them well, indicating that they are capable of processing new

content on their own. Emphasis is given on acknowledging the professional contributions of others by making appropriate references in their discussion.

***Recommendations:*** None.

**Outcome 3I – Ability to use techniques, skills, and modern engineering tools (analytical, experimental, computational, and design) necessary for engineering practice**

**Course Statistics**

<i>Course</i>	<i>Semester</i>	<i>Faculty Member</i>	<i>Enrollment</i>	<i># of students who passed</i>	<i>% of students who passed</i>
AE 171 A	Fall 2007	Dr. Nikos J. Mourtos	10	10	100%
AE 162	Spring 2010	Dr. Nikos J. Mourtos	29	24	83%
AE 171 B	Spring 2010	Dr. Nikos J. Mourtos	09	09	100%
AE 160	Fall 2010	Dr. Nikos J. Mourtos	24	15	63%

**Assessment Summary:** The performance target is met for Outcome 3I. Analytical, experimental, and design skills have been discussed extensively in Outcomes 3A, 3B, and 3C respectively. Hence, the emphasis in this outcome is on the use of modern software and laboratory equipment.

**Performance Criterion 3I-1:** Use modern software to conduct computer simulations, parametric studies, and ‘what if’ explorations.

**Performance Criterion 3I-2:** Use modern equipment and instrumentation in AE laboratories. (see Performance Criterion 3B-2).

**Assessment Summary:**

The performance target is met for Performance Criteria 3I-1 & 3I-2.

**Course Activities (AE160, AE162, AE168)**

- Use Sub2D, Wing Analysis<sup>22</sup>, AVL,<sup>23</sup> XFOIL<sup>24</sup>, XFLR5<sup>25</sup>, QPROP<sup>26</sup> to perform computer simulations and parametric studies of airfoils, wings, and other aerodynamic bodies.
- Use the AeroLab subsonic wind tunnel and instrumentation to perform 8 experiments: 3 experiments in AE160, 4 experiments in AE162, and one experiment in AE168 (new in Fall 2011).
- Use the Rolling Hills Research Corporation model 0710 water tunnel and instrumentation to perform a flow visualization experiment (AE160).

**Course Activities (AE171A&B)**

- Use the AAA (Advanced Aircraft Analysis) Program to conduct parametric studies, process optimization, and ‘what if’ explorations in the design of their airplanes.
- Use AutoCad, ProE, CATIA, and other CAD programs to make the drawings of their airplanes.

<sup>22</sup> < <http://www.desktop.aero/appliedaero/potential3d/wingcalc.html>>

<sup>23</sup> <<http://web.mit.edu/drela/Public/web/avl/>>

<sup>24</sup> < <http://web.mit.edu/drela/Public/web/xfoil/>>

<sup>25</sup> <<http://xflr5.sourceforge.net/xflr5.htm>>

<sup>26</sup> <<http://web.mit.edu/drela/Public/web/qprop/>>

- Use Sub2D, Wing Analysis<sup>27</sup>, AVL,<sup>28</sup> XFOIL<sup>29</sup>, XFLR5<sup>30</sup>, QPROP<sup>31</sup> to perform computer simulations and parametric studies of airfoils, wings, and other aerodynamic bodies.

**Assessment Tools:** Project reports, lab reports, design reports

**Student Performance Results**

	Students who scored 70% or higher
AE171A – Fall 2007	10 (100%)
AE162 – Spring 2010	24 (100%)
AE171B – Spring 2010	09 (100%)
AE160 – Fall 2010	15 (100%)

**Analysis**

Students are very competent in the use of modern software as well as in hands-on laboratory work.

**Recommendation:** None

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<sup>27</sup> < <http://www.desktop.aero/appliedaero/potential3d/wingcalc.html>>

<sup>28</sup> <<http://web.mit.edu/drela/Public/web/avl/>>

<sup>29</sup> < <http://web.mit.edu/drela/Public/web/xfoil/>>

<sup>30</sup> <<http://xflr5.sourceforge.net/xflr5.htm>>

<sup>31</sup> <<http://web.mit.edu/drela/Public/web/qprop/>>

## **D. BSAE Curriculum Improvements**

### ***Revised BSAE Focus Areas***

Two new focus areas were installed since the last ABET visit: (a) Aircraft Design and (b) Space Transportation and Exploration. These focus areas replaced the original three: (a) aerodynamics and propulsion, (b) structures and materials, and (c) dynamics and control. The new focus areas are aligned with the two options in our senior design capstone sequence: aircraft design (AE171A&B) and spacecraft design (AE172A&B). Within each of these focus areas students may, if they wish, focus through electives in design and manufacturing, management and economics, mathematics and numerical methods, applied physics, thermal-fluids, structures, materials, or controls and mechatronics (see Table 5.2).

### ***Strengthened the BSAE Core by including:***

- ***AE169 – Computational Fluid Dynamics***

AE169 was an elective course introduced by Dr. Papadopoulos in Spring 2005. AE169 was required in AY 2007–2008 for the following reasons:

- a. CFD has become an essential tool in AE in recent years with applications in both aeronautics and astronautics.
- b. Local industry has been requesting graduates with CFD skills.
- c. Graduating seniors, having become aware of the marketability of CFD in their resumes, recommended that AE169 become a required course.

- ***AE168 – Aerospace Vehicle Dynamics & Control***

AE168 replaced ME147 (Vibrations) as a required course in the BSAE curriculum and installed as a co-requisite for AE171A and AE172A and a prerequisite for AE171B and AE172B with a grade of “C–“ or better. AE168 includes an introduction to control theory as well as stability and control of aircraft and spacecraft. The replacement was made for the following reasons:

- a. AE faculty identified the need for “controls” in the BSAE curriculum early on and installed ME187 (Automatic Control System Design), as a required elective in the (old) “dynamics & control” focus area. The disadvantage of this arrangement was that unless a student selected “dynamics & control” as their focus area, they would not get any content in control theory. Furthermore, after the merger of AE and ME, the ME Program installed ME147, as a prerequisite for ME187 and AE students could no longer take ME187. At some point, without any discussion with AE faculty ME147 was installed as a required course in the BSAE curriculum. However, the “controls” content in ME147 is very limited and the course did not serve the needs of the AE Program.
- b. The “stability” content in AE165 is inadequate for design purposes in AE171B and AE172B. Hence, it became imperative that a follow-up course in stability and control of aerospace vehicles was required in the first senior semester.
- c. The AE faculty researched BSAE curricula across the US and discovered that more than 2/3 of the BSAE programs did not require “vibrations”. Among the schools that did not require vibrations were the following:

1. The University of Alabama in Huntsville
2. The University of Alabama
3. University of Arizona
4. Auburn University
5. Boston University
6. California Polytechnic State University, San Luis Obispo
7. California State Polytechnic University, Pomona
8. California State University, Long Beach
9. University of California, Davis
10. University of California, Irvine
11. Case Western Reserve University
12. University of Central Florida
13. University of Colorado at Boulder
14. Embry-Riddle Aeronautical University - Prescott
15. Embry-Riddle Aeronautical University - Daytona Beach
16. University of Florida
17. Georgia Institute of Technology
18. University of Illinois at Urbana-Champaign
19. Illinois Institute of Technology
20. Iowa State University
21. The University of Kansas
22. Massachusetts Institute of Technology
23. University of Minnesota-Twin Cities
24. University of Missouri-Rolla
25. State University of New York at Buffalo
26. North Carolina State University at Raleigh
27. The Ohio State University
28. Oklahoma State University
29. The University of Oklahoma
30. Princeton University
31. San Diego State University
32. University of Southern California
33. University of Texas at Arlington
34. University of Texas at Austin
35. United States Air Force Academy
36. United States Naval Academy
37. Virginia Polytechnic Institute and State University
38. University of Virginia
39. West Virginia University
40. Wichita State University

Furthermore, it was observed that AE programs in the US, which did require “vibrations”, were all merged with ME programs, hinting that the impetus for a required “vibrations” course was a matter of economy in a merged department.

- *AE160 – Aerodynamics I*

AE160 is a lecture/lab course, which replaced ME111 (Fluid Mechanics) for the following reasons:

- a. Introduction of a 2<sup>nd</sup> aerodynamics course allows a proper introduction to boundary layer theory as well as aerodynamic drag calculations, which is prerequisite knowledge for AE171A&B and AE172A&B.
- b. While AE students took ME111 as a required course, they scored on average 10% – 30% on the Fluid Mechanics Concept Inventory (FMCI), indicating that their working knowledge of fluid mechanics was at unacceptable levels. In particular, they averaged 0% – 10% on boundary layer concepts. When students came into AE162 with this level of background knowledge it became impossible to include drag calculations without a proper presentation of boundary layer theory. However, there was not sufficient time in AE162 to do both.
- c. Introduction of a 2<sup>nd</sup> semester aerodynamics course allows for 8 aerodynamic experiments to be split between AE160 and AE162 with a full lab report for each; students used to do only four of these experiments in AE162. With the limited number of experiments available in the old AE162, AE students not only did not get boundary layer theory, they also missed an opportunity to perform a boundary layer experiment in the Aerodynamics Lab due to lack of time.

### ***Strengthened the Mathematics Base***

Math129A (Linear Algebra) replaced ME130 (Applied Engineering Analysis) as a required course because a large percentage of graduating seniors indicated in their exit interviews that the content of ME130 was review of what they already knew from previous math courses. ME130 does cover linear algebra, however, the amount of time dedicated to the subject (2 weeks) is insufficient for students to acquire working knowledge of the material. Linear algebra has now been installed as a prerequisite for AE169.

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