Meaning of Degree:

Generic Degree
The MSE-AE degree provides the student with the advanced knowledge necessary to successfully address the significant challenges confronting the field of aerospace engineering utilizing a solid foundation of advanced courses that are relevant to current industry research, design, development, analysis, and testing practices.

The areas of study include both aeronautics and astronautics related disciplines that are in demand by industry and government agencies: aircraft structures, astronautics, air-breathing propulsion, missile engineering, computational fluid dynamics, structural dynamics, robust control of nonlinear systems, digital flight control systems, optimal control and estimation, hypersonic aerodynamics, aircraft system identification, orbit determination, aerodynamics of wings and bodies, aircraft design, and research project.

Distinctive features
Through a careful selection of challenging courses and projects, graduate students propose creative approaches to solving selected contemporary engineering problems. These experiences distinguish the CPP MSE-AE graduate by providing them with the design and execution background to tackle complex problems using innovative approaches that can be applicable in industry and research.

For example, recent student projects include the development of an optimization schema for deflecting the flight control surfaces to minimize drag of a Boeing-type Blended Wing Body aircraft with an aeroelastic wing, nonlinear adaptive control of UAV’s (NSF funded), Next-Gen Satellite Communication, fluid structure interaction in solid rocket rocket motors (AFRL application), UAV Collision Avoidance (Lockheed Martin application), aircraft performance modeling (USAF Flight Test Center application), and others.

Also, since many of our part-time instructors either still work in industry or have recent extensive industry experience, the teaching and curriculum is uniquely qualified to be updated and made relevant to current industry practices and needs. This further prepares the students to immediately contribute to their employer’s technical and programmatic needs upon completion of their Master’s program.

Examples of various instructor’s practical industry experience include 1) 26 years of experience in aerospace engineering research and development, flight test pilot, and astronaut candidate (at Virgin Galactic, NASA Dryden, US Airforce, US Navy, John Hopkins APL; Dr. S. Corda), 2) 15 years in thermal fluids engineering and structural dynamics and aeroelasticity (at Boeing, JPL,
ATK, NREL, NCAR; Dr. K. Anderson), 3) 12 years in conceptual design sizing and CAD design (at Lockheed Martin; Mr. R. Lawhon), 4) 16 years in space mission design and guidance, navigation and control, (at JPL, Mr. T. Lam), 5) 47 years in aeromechanics, airframe structures and materials (at NAWC and Jacobs; Dr. C. Porter), 6) 29 years in systems engineering and spacecraft propulsion and astronaut candidate (at NASA Johnson, JPL; Mr. J. Lewis), 7) 19 years in hypersonic vehicle and missile design and testing, rocket propulsion (at NASA Dryden; Dr. T. Bui), and others.

Mission and Program Educational Objectives Alignment with the University vision, values and outcomes.

The university vision and mission statement is:
“Cal Poly Pomona's mission is to advance learning and knowledge by linking theory and practice in all disciplines, and to prepare students for lifelong learning, leadership and careers in a changing multicultural world.”

Figure 1 illustrates the creation and updating process for the program Vision, Mission, PEO’s (Program Educational Outcomes), SO’s (Student Outcomes) and Course Objectives. These program goals flow from the University Mission statement, which flows down to the CoE Mission statement, then to the Aerospace Engineering Vision and Mission Statements. Then the program PEO’s, SOs, and finally the course objectives flow from the program vision and mission statements to ensure that all goals in the chain are supportive and inclusive of the one(s) above it.

The CoE Mission statement is:
“The Mission of the Cal Poly Pomona College of Engineering is to produce well-qualified engineering graduates who are ready for immediate and productive entry into the workforce or for graduate studies. The college does so by providing practice-oriented education based on sound engineering principles and applications, while also emphasizing the teamwork, communication and creative skills needed to be leaders in a global society.”

MSE-AE Program Vision:
“The vision of the MSE-AE Program is to produce nationally recognized aerospace graduates who can contribute to achievements in national defense, space exploration, commercial aerospace, aeronautics, and academia.”

MSE-AE Program Mission:
“The Mission of the MSE-AE Program is to provide an education by hands-on application of theory to produce graduates for a diverse society who can contribute immediately, effectively and ethically to the development of aerospace products and possess the educational foundations for their career growth in industry and academia, with innovation and leadership.”

Figure 1 shows the alignment flow process for creating and/or updating the Aerospace Engineering Vision, Mission, PEO’s, SO’s and Course Objectives linked to the university.
Entering student’s abilities

Entering student’s abilities are determined by the following background requirements:
- B.S. in Aerospace, Mechanical engineering from an ABET accredited institution received within the last 5 years.
- GPA in upper-division undergraduate courses in Math, Science and Engineering needs be ~3.0 or higher.
- If B.S. received from non-ABET institution or prior to 5 years ago or lower GPA than ~3.0, but higher than ~2.85, then GRE test score (quantitative + verbal) of at least 301 is required.
- Also visit Cal Poly Pomona Admissions Office at CPP website: www.cpp.edu

Key entrance abilities include proficiency in the analysis and problem solving at the undergraduate level in aerospace related mathematics and physics, structures, propulsion, flight controls, aerodynamics, orbital mechanics, aircraft and missile configuration design, simulation and programming methods, technical writing, and oral presentation skills. The Department accommodates the entering students’ abilities by allowing them to tailor their Master’s projects to the topics related to their current job position.
MSE-AE Graduates culminating skills

MSE-AE graduates culminating skills depend on the required courses and elective topics chosen. Skills are proficiency at the Master’s level including advanced aircraft structures design and analysis, astronautics, air-breathing propulsion, missile engineering, computational fluid dynamics, structural dynamics, robust control of nonlinear systems, digital flight control systems, optimal control and estimation, hypersonic aerodynamics, aircraft system identification, orbit determination, aerodynamics of wings and bodies, aircraft design, and the ability to conduct independent research.

Additional information can be found at the Department website:
http://www.cpp.edu/~aro/

Quality of the Degree:

How the program helps students engage and master the key Program Learning Outcomes

After completing the proposed MSE program, the graduate will be able to:

1. Develop an understanding of advanced mathematical and numerical methods to effectively address real world engineering problems - This is accomplished primarily through applying basic mathematical methods to solve engineering application homework problems in multiple courses;

2. Analyze and design complex aerospace structural elements - This is accomplished in the courses that involve design as a key curriculum element such as the aircraft design and missile engineering courses;

3. Perform graduate-level aerodynamic analysis - The key course is the Computational Fluid Dynamics course which enables the student to model and solve complex, non-linear aerodynamic problems and configurations;

4. Analyze sophisticated air-breathing propulsion systems - Accomplished in the course with the same title;

5. Perform in-depth analysis of flight dynamics of aircraft and spacecraft and design advanced flight control systems - This area has been identified by the Air Force Research Laboratory (Mr. Mike Huggins, Chief Engineer) as a key skill, since the future of aerospace systems is autonomous control of unmanned aircraft, ground vehicles, spacecraft, and water-based vehicles. This includes automated coordination between swarms of these systems for collision avoidance and cooperative missions;

6. Develop an ability to work efficiently in teams charged with the design of complex systems such as spacecraft from a conceptual design perspective - This is accomplished during course work that requires team projects;

7. Demonstrate excellent oral, written and graphic communications skills - This is primarily accomplished in the Master’s Project oral presentation to the faculty and the submission of the Master’s Project’s final report. The chosen topic is expected to further the understanding of an advanced aerospace engineering topic. Many students
choose a topic they are working on at their current job, which is almost always an aerospace engineering company or government organization.

Program Outcomes are reviewed on a two-year cycle based on the judgment of the Aerospace faculty, with advice from employers and alumni provided through the Aerospace Industry Action Council (IAC). The Council typically consists of representatives from the local aerospace industry. In addition, several of the representatives are alumni of the Department. Therefore, this is an ideal group to provide timely input from alumni and employers.

Table 1 shows the relationship of student outcomes to courses, and the level of proficiency at the “Practice” or “Masters” level.

### Table 1: Relationship of Program Learning Outcomes to Required Courses

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Outcome 1</th>
<th>Outcome 2</th>
<th>Outcome 3</th>
<th>Outcome 4</th>
<th>Outcome 5</th>
<th>Outcome 6</th>
<th>Outcome 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARO 506</td>
<td>P</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARO 509</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>ARO 510</td>
<td>P</td>
<td>P</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGR 511</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGR 512</td>
<td>M</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARO 577</td>
<td>P</td>
<td>P</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARO 578</td>
<td>P</td>
<td></td>
<td>P</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGR 692</td>
<td>P</td>
<td>P (or M)</td>
<td>P (or M)</td>
<td>P(or M)</td>
<td>P(or M)</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

P = “Practice” and M = “Master”—level, depending on the topic of the final project.

More information on the programs curricular requirements, learning outcomes, and other aspects if found at:
http://www.cpp.edu/~engineering/ARO/masters.shtml

---

**Integrity of the Degree:**

Our program is accredited by the WASC. The program uses appropriate processes for assessing and evaluating the extent to which the student outcomes are being attained.

Our department utilizes direct assessment instruments of the Master’s Student Outcomes including the faculty’s evaluation of the student Master’s Project final report and oral presentation. Indirect measurements include the Master’s Alumni survey. These evaluations are used to verify that the students are achieving the outcomes at the expected level, update or add...
curriculum, introduce new teaching methodologies (such as, planning for distance learning from the Lancaster site to the Cal Poly Pomona campus, and addition of new Master’s courses to be taught at the Pomona campus), identify needs for increasing department faculty, and identify needed improvements in laboratory equipment. The oral presentation and the report for the Master’s Project is used to verify that sequence of student learning experiences has achieved its purpose. Our on-going assessment plan is shown in Table 2.

Table 2: Proposed Assessment Plan for next Academic Year

<table>
<thead>
<tr>
<th></th>
<th>F-17</th>
<th>W-18</th>
<th>S-18</th>
<th>Su-18</th>
<th>F-18</th>
<th>W-19</th>
<th>S-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 1</td>
<td></td>
<td></td>
<td>C ARO-577</td>
<td></td>
<td></td>
<td>C ARO-577</td>
<td></td>
</tr>
<tr>
<td>Outcome 2</td>
<td>C ARO-512</td>
<td>C EGR-512</td>
<td></td>
<td></td>
<td></td>
<td>C EGR-512</td>
<td></td>
</tr>
<tr>
<td>Outcome 3</td>
<td></td>
<td></td>
<td>C ARO-578</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 4</td>
<td>C ARO-510</td>
<td></td>
<td></td>
<td></td>
<td>C ARO-510</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 5</td>
<td></td>
<td></td>
<td>C EGR-511</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 6</td>
<td>C EGR-692</td>
<td></td>
<td></td>
<td></td>
<td>C EGR-692</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 7</td>
<td>C EGR-692</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C EGR-692</td>
<td></td>
</tr>
</tbody>
</table>

C: Collection of Assessment Data and Analysis, D: Discussion of Assessment Result

Procedures for Collection of Assessment Data and Analysis

Direct Data:
The following measurements are used to assess each learning outcome:

- Evaluation of student Master’s Project report, as well as the final student oral presentation.
- Faculty assessment of student oral presentations, written reports, and the final examinations of the courses.

Indirect Data

- Three-year assessment of program objectives by Alumni Surveys. Alumni Surveys are analyzed for potential improvements for faculty review.
- External evidence of the value of the program is evaluated by the feedback from the Aerospace Industry Action Council (IAC) members who hire our graduates.

Discussion of Assessment Results
The Graduate Committee reviews assessment results and discuss how to improve teaching and learning as well as inform planning and decision-making. The results can highlight successes such as these:
• Evidence that students are meeting or exceeding learning expectations:

Mr. Mike Huggins, the AFRL sponsor of the Masters’ program and member of the Department Industrial Action Council (IAC), has made several assessments over the past few years of the program, and verbally concluded that the program has been very effective for developing the skill-sets for his employees at AFRL. This conclusion has been validated by his enthusiastic continuation of funding for the program. This addresses the technical skills Learning Outcomes 1 through 5.

• Better alignment of the curriculum with desired outcomes:

The opportunity to select many instructors with extensive industry experience has driven the curriculum to contain real world examples and be relevant to real aerospace industry needs, especially in the propulsion and astronautics courses taught by instructors employed by JPL. This addresses Learning Outcome 6.

• Further opportunities for Team Projects:

This year, two MS students have teamed as advisors and technical contributors with an undergraduate Senior Project on our Pomona campus. This served as their MS project. This enables the MS students to gain additional team working and mentoring skills as well as offering them a project that has experimental data generated by the undergraduate students for correlating the Master’s Project theoretical models. This win-win relationship will be further expanded in the future. This addresses Learning Outcome 6.

• Development of explicit standards and corresponding samples of student work:

The student project final report now has a specific template for the students to use to ensure all important topics are covered. This has improved the quality and scope of the project final reports. This addresses Learning Outcome 7.

MSE-AE Alumni survey results and assessment of Learning Outcomes example

One of the MSE-AE alumni answered the survey questions, typical of others’ comments. These address specifically Learning Outcomes 1-5, 6, and 7.

A. Are there relevant topics the Department did not cover or topics, which should have been covered in greater depth?

“I believe the department did a very good job in covering the major topics that would be needed by most entry level engineers working in the Aerospace Industry. I felt that they did a great job finding experts in the field with valuable experience and knowledge of what the demands of the industry are. These professors were able to tailor the lessons so that more relevant topics could be focused on.”

B. What aspects of the MSE-AE Program were most memorable and/or beneficial?
“It seemed like the most challenging courses were also the most beneficial. Some of the aerodynamics and aircraft design courses were very well taught and very applicable to my job. In addition to that, some of the major projects involving team design efforts were very valuable in that they emulated the actual work environment very nicely. Finally, the end of program thesis project really gave me a wide spectrum of experience and research techniques that have already proven to be valuable to me in my career at The Air Force Research Laboratory.”

C. What aspects of the MSE-AE curriculum or faculty do you feel could be improved?

“The quarter schedule made it fairly taxing for people such as myself who were working full time in addition to taking these classes. Having to attend 4-hour night classes two times a week after work proved to require a decent amount of endurance.”

Assessment of alumni surveys

The student alumni assessments, such as in above, also indicate the MSE-AE program is on track in meeting key student technical outcomes 1-5. The scheduling of the night courses at four hours once per week is a challenge. Dividing the courses into two sessions per week at two hours each would help, but that often requires a Pomona-based instructor to drive over 200 miles two times per week instead of once, which is also taxing. Twice per week sessions are being investigated for the instructors that live close to the Lancaster campus.

Example of a Learning Outcome assessment program change

Assessments and observations of Learning Outcome 7 indicated that the students scheduling of the Master’s Project needs to be extended an extra quarter to allow more time to complete the technical work while writing a quality report and preparing the oral presentation. This change is being implemented in a case by case basis.

Example of MSE-AE Program expansion investigation

Many students and faculty have expressed a strong interest in also offering MSE-AE courses at the Pomona campus to augment the Lancaster campus. This expansion is under consideration and resources and impacts are being defined for potential implementation in the future.

More information regarding assessment is at:
http://www.cpp.edu/~engineering/ARO/outcomes.shtml