# Sponsor Guidelines AY 2022/23

Senior Projects (ASEN 4018 & 4028)

## Introduction

All undergraduates in [Aerospace Engineering Sciences (AES)](http://www.colorado.edu/aerospace/) are required to take a two semester capstone projects course sequence. This sequence includes *ASEN 4018 Senior Projects I: Design Synthesis* (Fall semester) and *ASEN 4028 Senior Projects II: Design Practicum* (Spring semester).The course will be taught by a team consisting of 10 faculty members[[1]](#footnote-1) and three staff members, called the Project Advisory Board (PAB), along with the two course coordinators.

This document provides guidelines for the scope of a typical Aerospace Engineering Sciences (AES) Senior Design project along with sponsor benefits and expectations. When defining a project, sponsors should understand that the purpose of the AES Senior Projects curriculum is to provide undergraduate students with a first-hand experience with a ***requirements-based design process*** carried out by largely ***self-directed teams***, employing ***fundamental engineering principles*** to make design choices and to develop and communicate an ***engineering understanding*** of the system they design. All project concepts should have a **clear purpose** with a recognized value to industry or society with **specific functional objectives**, yet provide **significant design challenges** that allow students to explore various design solutions and make design choices based on **sound engineering reasoning**. At the same time, projects must be scoped such that the level of complexity is compatible with 10-12 person teams of engineering seniors working an average of 16 hours each per week for 28 weeks.

Sponsors can view deliverables of projects from previous years at the Senior Design Projects website: <http://www.colorado.edu/aerospace/industry-home-page/senior-design-projects>.

## Senior Projects Course Content

Senior Projects is the capstone course in the Aerospace Engineering Sciences (AES) curriculum at the University of Colorado Boulder. While a capstone experience is required by all accredited engineering programs[[2]](#footnote-2) the AES department offers a rigorous two-semester course where students move through a **requirements-based design** **process** from concept to detailed design to manufacturing to test and finally validation. Students work in **self-directed teams**. A team typically consists of 10-12 Aerospace Engineering students of senior standing. Each team is assigned one faculty advisor from the Project Advisory Board (PAB) pool. These faculty members cover a wide range of technical skills and have a variety of design experience to guide the teams through the design process for their particular project. Advisors will formally meet with their teams for at least one hour each week.

Projects are expected to provide an integrative design experience that includes topics typically of an aerospace nature that allow for creative latitude in arriving at a final design. All projects must include design elements from **mechanical, electrical, and software** subsystems. The course seeks to expose students to systems engineering principles and the multidisciplinary nature of modern engineering problems; hence each of these three components must represent a substantial part (at least 25%) of the design work. The projects begin with a **requirements definition phase** where students use the technical and design skills developed throughout the undergraduate Aerospace Engineering Sciences curriculum to determine the functional requirements and scope of the design work to be done. These skills are applied throughout the course, leading to a physical prototype that is **manufactured and tested.** During the testing phase teams seek to **verify** that the initially-defined requirements are met and finally **validate** that the design serves the intended purpose. Given the difficulty of testing complete aerospace systems in a relevant environment, many projects focus only on important aspects of an entire system that can be **safely** tested under laboratory or limited flight conditions.

Each student must have a well-defined role on their design team, and **demonstrate leadership** in at least one aspect of project development and execution.

## Senior Projects Course Structure

At the beginning of the first semester (Fall) of the course (ASEN 4018) students are presented with the slate of available projects identified by the sponsor, provided through the **Notice of Intent (NOI)** forms, and described by **short sponsor presentations** that take place during the first week of class. Students then submit a survey where they choose up to two colleagues that they wish to work with, state their strengths in terms of mechanical, electrical, software, and management skills, and then rank all projects from most to least desirable. A fair rank-optimal matching algorithm matches students into teams of 10 to 12 students, ensuring all teams have a balance of mechanical, electrical, and software skills. Since implementing this algorithm in AY 2020, all students have been assigned to a project that was one of their top three choices. Teams and their projects are reviewed by the faculty and finalized by the beginning of the second week of class. Teams then work with sponsors to develop the **Project Definition Document (PDD)** that defines the project, establishes top-level functional requirementsand articulates measures of success for the project. Once the sponsor and team agree to the terms laid out in the PDD, the design work begins by generating top level design concepts and conduct initial trade studies to identify a baseline architecture and corresponding design requirements. This baseline design is then analyzed for feasibility, and presented to the PAB at a **Preliminary Design Review (PDR).**  Projects deemed to be feasible by the PAB then progress to subsystem requirements development, detailed design, budgeting, scheduling, and preparation for the **Critical Design Review (CDR)** at the end of the fall semester. At CDR, each team has one hour (including questions) to present the key design elements of the project and convince the PAB that the project is likely to succeed and parts are ready to be ordered or manufactured. The fall term concludes with a written **Fall Final Report (FFR).**

The spring term begins with parts ordering (long lead items can be ordered earlier), electrical and mechanical manufacturing, and detailed software development. Teams present their mechanical, electrical, and software fabrication and integrations plans to subject matter experts the first two weeks of the semester. Feedback is incorporated the teams continue to fabricate and assemble their projects, and develop detailed test plans in preparation for **the Test Readiness Review (TRR)** in the second month. Testing to verify design requirements and validate the suitability of the design occupy the third month of the term, in preparation for the **Spring Final Review (SFR)** near the end of the term. The course concludes with a written **Project Final Report (PFR)**. A final course requirement is to present their project at a one day **Aerospace Senior Projects Symposium** for professional engineers and recruiters and to the general public at the **College Design Exposition**.

## What is Expected from Project Sponsors?

Corporations, companies, small businesses, national laboratories, R&D organizations, and academic faculty members may become project sponsors.

Within the framework of the Senior Design course, all projects are conducted on a ***best effort***basis by students, guided by a member of the AES PAB. The sponsor should understand that our primary goal is the education of aerospace engineering students, and as such *exploratory* or *proof-of-concept* projects can be quite successful as an undergraduate capstone senior project. Projects that are in the sponsor’s critical path generally cannot be accepted as Senior Design projects unless the sponsor takes full responsibility for the outcome. “Good-to-have” results and “off-ramp” studies are more likely to be suitable. Sponsoring a project should also be seen as a “**training-on-the-job**” activity and a “**9 month interview**” for potential future employees. Although faculty and students endeavor to make every project a success, the University of Colorado cannot take any responsibility for results deemed by the sponsor as “insufficient.”

### Sponsor Participation in the Course

The sponsor provides a one to two paragraph project definition on the **Notice of Intent (NOI)** form to the AES Senior Projects Coordinator. In addition to the project definition, the NOI must also provide **the name and contact information of the sponsor’s technical expert**, who will work with the student team during the project definition stage, and **the name and contact information of the sponsor’s contracting expert**, who will work with the University’s contracting department to set-up the necessary structures to fund the project. Please note that the **contracting expert should be the one to sign the NOI** on the sponsor’s part. During the first week of the semester the teams will be introduced to each project through **short sponsor presentations**. The next four weeks of the fall semester teams spend working with the technical expert as they develop the **PDD,** which typically requires a time investment of at least one hour per week for those four weeks. Once this document is complete regular status reports will be provided as design work continues, the manner and frequency of these status reports are negotiated between the project team and the sponsor. Such close contact with the team during the early project definition phase, in particular, is critical for success of the proposed project. The period leading up to PDD is often considered the most difficult learning stage by students, who are exposed to a rigorous requirements-based design process for the first time. Sponsor involvement in the course review process (PDR, CDR, SFR) is encouraged, either in person, or in separately arranged sponsor reviews of the materials.

In summary, project sponsors are expected to:

* Complete a Notice of Intent form (NOI), and work with the University to establish funding for the project in a timely manner.
* Prepare and give a short presentation introducing the project to the senior class.
* Review and negotiate the Project Definition Document (PDD) with the students.
* Provide the project team with advice and feedback on submitted documents and presentations.
* If possible, participate in major project reviews (PDR, CDR, SFR) and, if desired, organize separate reviews.

### Project Resources Available to Sponsors

Sponsors are asked to provide adequate resources for their proposed project. In return, AES facilities, students, staff, and faculty become resources for the sponsor.

The sponsor’s prime resources in the project are the senior students. The sponsor has the opportunity closely observe the student’s capabilities while mentoring them toward project success. Over the course of two semesters (28 weeks), a student team of 10 - 12 members is required to spend at least 4480 – 5376 person-hours working[[3]](#footnote-3) on their senior project.

Each team is assigned one faculty advisor from the Project Advisory Board (PAB) pool. Each faculty member of the PAB spends about 110 hours advising a particular project. The PAB faculty and staff members each contribute another 15-20 hours per project during the reviews and evaluations of all projects, providing expertise and feedback on project technical and organizational aspects.

All senior design teams have priority access to the Aerospace Engineering Sciences machine shop and electronics lab. The students receive design and manufacturing guidance from full-time machinist, full-time electronics technicians and full-time software technicians. These departmental staff members contribute a substantial number of hours (ranging from 60-100% of their time) with the teams to help make their projects successful; thus a portion of their salaries and those of auxiliary support staff must be covered by the senior design project funding.

Over the past years of teaching senior projects, the AES department has committed a considerable amount of general funds resources to develop the curriculum and materials for the Senior Projects course. Budgetary constraints require that external funding be sought to supplement department costs so that our program remains sustainable.

All faculty members of the Aerospace Engineering Department have agreed to support senior design teams if approached with project-related questions, providing a broad and deep base of expertise and experience for the students to draw upon. Students are also encouraged to seek out other sources of expertise, information, and advice from industry and the engineering literature to support their design decisions.

Each project is required to provide a total cost projection at the end of the course, under the assumptions that the work was carried out in an industry setting with entry level engineers. These projections regularly total more than $300,000.

### Project Resources

The department of Aerospace Engineering Sciences has established a preferred avenue for sponsors who would like to support a two-semester senior design project, and a corresponding standard contract template. An outline of this support is provided below:

**Sponsor support**. An AES Senior Design Project requires a **minimum funding level** of **$20,000** (additional fee are added if the University’s standard contract is not used), which is subdivided as follows:

* Project-specific expenditures for project-specific materials, parts, software: $5000 minimum. Amount varies by project at the discretion of the sponsor as well as project needs.
* Department infrastructure and labor fees for the senior projects (instructors and shop staff salary, maintenance for manufacturing shop, electronics shop, computer labs, materials, supplies, disposables): $15,000.
* Additional in-kind support (e.g. lending of hardware, access to test facilities, etc.) is sometimes needed, depending on the focus and scope defined for the project. The sponsor shall clearly define the specifics of the in-kind support.

Support agreements are handled either as contracts through the University of Colorado office of Contracts and Grants or as gifts through the CU Foundation. **The support agreement must be in place no later than at the start of the Fall semester**, so that only viable projects are presented to the students for team selection.

**Students** may submit proposals to other funding sources in order to supplement their base funding (with sponsor approval), e.g., the Engineering Excellence Fund of the College. Often other companies offer in-kind donations, for example software packages or instruments, academic discounts, etc. However, projects must be conceived and scoped so that minimum success does not depend on receipt of supplementary funds that may or may not become available.

**Special Arrangements.** In exceptional cases other arrangements can be negotiated between a sponsor and the Department of Aerospace Engineering Sciences. See the contact information at the end of this document.

### Project Deliverables

Sponsors receive the following deliverables from their sponsored student team:

1. Fall Final Report (FFR). PDF-document containing a comprehensive description of the design at the CDR level, including mechanical/electronics/software drawing packages
2. Project Final Report (PFR). PDF-document containing a complete description of the project and all test results.

Sponsors can also download the following publicly available deliverables from all project teams:

1. Project Definition Document (PDD) Data Package (PDF-document)
2. Preliminary Design Review (PDR) Data Package (PDF-document)
3. Critical Design Review (CDR) Data Package (PDF-document)
4. Test Readiness Review (TRR) Data Package (PDF-document)
5. Spring Final Review (SFR) Data Package (PDF-document)

Project descriptions and deliverables are posted on the senior projects website <http://www.colorado.edu/aerospace/industry-home-page/senior-design-projects>. This is to comply with export control restrictions and the educational mission of the course. Details on the class export control policy can also be found at <http://www.colorado.edu/aerospace/sites/default/files/attached-files/aes-srp-export_control_policy_0.pdf>.

Separate review presentations (meeting or internet) may be arranged between the sponsor and their sponsored senior design team, provided they do not conflict with course review schedules.

All components purchased from project funds will remain in the AES department for possible future use in another project or in class. However, surplus project hardware and software may be released to the sponsor upon request. Please indicate on the NOI whether or not you are interested in receiving surplus project equipment after course completion; be sure to coordinate with the student project team and course coordinators regarding hardware availability and readiness for pickup.

According to the standard contract for Senior Projects, any **Intellectual Property (IP)** rights resulting from the supported senior design project remains with the inventor(s), i.e. the students.

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| **Acronym** | **Definition** |
| --- | --- |
| NOI | Notice of Intent (form) |
| PDD | Project Definition Document |
| PDR | Preliminary Design Review |
| CDR | Critical Design Review |
| FFR | Fall Final Report |
| TRR | Test Readiness Review |
| SPR | Spring Project Review |
| PFR | Project Final Report |

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| United Launch Alliance |
| U.S. Nordic Ski Team |

**History of Recent Projects**

Potential sponsors are encouraged to visit the AES Senior Design course webpage at <http://www.colorado.edu/aerospace/current-students/undergraduates/senior-design-projects> to browse recent projects and to examine the project deliverables.

**Contacts**

| **Title** | **Name** | **Phone** | **Email** |
| --- | --- | --- | --- |
| Department Chair | Dr. Brian Argrow | 303-492-8183 | aeschair@colorado.edu  |
| Course Coordinator | Dr. Jelliffe Jackson | 303-492-3702 | aesseniorprojects@colorado.edu |
| Course Coordinator | Dr. Kathryn Wingate | 303-735-7631 | Kathryn.Wingate@colorado.edu  |
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1. Number of faculty on the PAB depends on number of available projects and the size of the senior class. [↑](#footnote-ref-1)
2. See <http://www.abet.org> for more information. [↑](#footnote-ref-2)
3. 10 students x 4 credits x 4 hours/credit/week x 28 weeks (2 semesters) [↑](#footnote-ref-3)