1 Introduction

All Interdisciplinary Telecom Program (ITP) graduate students are required to take a two semester Graduate Projects course sequence. This sequence includes TLEN 5700: Research Methods (Fall semester) and TLEN 5710: Graduate Capstone Projects (Spring semester).

This document provides guidelines for the scope of a typical ITP Graduate project along with sponsor benefits and expectations. When defining a project, sponsors should understand that the purpose of the ITP Graduate project curriculum is to provide graduate 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 and aims must have a level of complexity that is compatible with 5 - 6-person teams of graduate students working an average of 16 hours each per week for 28 weeks.

Sponsors can view deliverables of projects from previous years at the ITP Graduate Capstone Design Projects website: https://www.colorado.edu/p1198848cc19/

2 Senior Projects Course Content

TLEN 5700 and TLEN 5710 are the capstone courses in the Interdisciplinary Telecom Program (ITP) curriculum at the University of Colorado at Boulder. ITP offers a rigorous two-semester course where students move through a requirements-based design process from concept to detailed design to test and validation. Students work in self-directed teams. A team typically consists of 5 - 6 ITP students of 2nd-year graduate standing. Each team is assigned one faculty advisor. These faculty members cover a wide range of technical skills and 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.

The fundamental course objective of the ITP Graduate Projects sequence (TLEN 5700 / 5710) is to teach students how to engineer a complex, inter/multidisciplinary design and implementation problem in a group environment. Graduate Projects focuses on the synthesis and application of basic science, mathematics, engineering theory and design skills. The course teaches basic knowledge in component
and systems engineering design and provides an introduction into project management, including financial responsibility.

Projects begin with a requirements definition phase and students will make use of the technical and design skills developed throughout the graduate Interdisciplinary Telecom Program curriculum. All projects must lead to a prototype that is designed and tested, leading up to a verification of the initially-defined requirements and some level of validation that the design serves the intended purpose. Given the difficulty of testing complete 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 conditions.

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

### 3 Graduate Projects Course Structure

At the beginning of the first semester (Fall) of the course (TLEN 5700) students are presented with the slate of available projects identified by the sponsor-provided Notice of Intent (NOI) forms and described by short sponsor presentations in the first week of class. Students then self-select a project through two rounds of voting so that the projects are approximately evenly staffed. Teams and their projects are finalized by the second week of class. After selecting their projects, teams work with sponsors to develop the Project Definition Document (PDD) that defines the project and its top level functional requirements and articulates the measures of success for the project. Teams then begin the design process by generating top level design concepts and conduct initial trade studies to identify a baseline architecture and corresponding design requirements. This is documented in the Conceptual Design Document (CDD). Projects deemed to be feasible by the ITP faculty 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 ITP faculty that the project is likely to succeed and equipment/parts are ready to be ordered or manufactured.

The spring term begins with parts ordering (long lead items can be ordered earlier). 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. A final course requirement is to present their project at a one-day ITP Spring Colloquium for professional engineers and recruiters.

#### 3.1 Graduate Projects Participation Timeline & Overview

Project sponsor deadlines and important dates include:

- **August 01, 2018**: Complete Notice of Intent Form
- **August 15, 2018**: Submit a required written project pitch, and optional video pitch
- **Mid-September**: Meeting with Graduate project team to confirm project assignments
• **Throughout Fall semester:** Be available to help the team refine project goals and scope during early part of Fall semester. Work with team to identify a meeting/communication pattern.

• **November 1, 2018:** Submit the donation/fee.

• **Mid-Spring semester and end of semester:** Provide feedback on team progress and fill out final Team Evaluation Forms.

• **April 24, 2018:** Attend ITP Spring Colloquium

### 4 Project Sponsor Benefits

In return for a sponsor’s investment, ITP facilities, students, staff and faculty all become resources for the sponsored team. The sponsor can directly observe and mentor their team in action, solving complex multi/interdisciplinary problems while learning/exercising engineering skills at the same time.

All ITP Graduate design students become familiar with the sponsoring organization as the assigned team learns about the company’s needs and goals to successfully complete the project and share this information to the entire class. This is great exposure for companies for future hiring of students and interactions with faculty.

### 5 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 Graduate Projects course, all projects are conducted on a **best effort** basis by students, guided by a member of the ITP faculty. The sponsor should understand that our primary goal is the education of ITP students, and as such exploratory or proof-of-concept projects can be quite successful as a graduate-level graduate project. Projects which are in the sponsor’s critical path generally cannot be accepted as projects unless 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.”

#### 5.1 Sponsor Participation in the Course

The sponsor provides a one to two-page project definition on the **Notice of Intent (NOI)** form to the ITP Graduate faculty instructor and ITP Corporate Outreach Manager and develops a more detailed **Project Definition Document (PDD)** with the students. During the two-semester Graduate Projects course, the sponsor has many opportunities to mentor and help train a group of about 5 - 6 students. All sponsors are expected to become active participants in their sponsored project. Sponsors should name a contact person for the project who can dedicate an average of at least one hour per week to the project. Close contact with the teams 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. Sponsors involvement in the course review process (CDR and SFR) is essential, 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 course coordinator to establish funding for the project in a timely manner.
- Review and negotiate the Project Definition Document (PDD) with the students.
- Provide the project team with advice and feedback on submitted documents and presentations.
- Participate in major project reviews (CDR and SFR) or, if possible organize separate reviews.
- Provide input to the advising faculty who determine the grades for teams and individual students.

5.2 Project Resources Available to Sponsors

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

The sponsor’s prime resources in the project are the senior graduate students. The sponsor has the opportunity to closely observe the student’s capabilities while mentoring them toward project success. Over the course of two semesters (28 weeks), a student team of 5 - 6 members are required to spend 4480-5376 person-hours working on their senior project. In the past, students have spent even more time on average working on their project, as documented in weekly timesheets.

Each team is assigned one ITP faculty advisor. Each faculty member spends about 110 hours advising a particular project. The ITP faculty 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 project design teams have priority access to the ITP Telecom Lab, Wireless Networking Lab, and Cybersecurity Lab. The students receive guidance from ITP lab support personnel. These department staff members contribute a substantial number of hours (ranging from 60-100% of their time) with the teams to help make their projects successful.

Over the past decade of teaching Graduate Projects, the Interdisciplinary Telecom Program has committed a considerable amount of general funds resources to develop the curriculum and materials for the Graduate Projects course.

All faculty members of the Interdisciplinary Telecom Program have agreed to support Graduate 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.

5.3 Project Resources

ITP has established a preferred avenue for sponsors who would like to support a two-semester Graduate project, and a corresponding standard contract template. An outline of this support is provided below:

**Sponsor Support.** An ITP Graduate Design Project requires a **minimum funding level** of $20,000, 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 projects (lab staff salary, maintenance for 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 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 Interdisciplinary Telecom Program. See the contact information at the end of this document.

5.4 Project Deliverables

Sponsors receive the following deliverables from their sponsored student team:

1. 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:

2. Project Definition Document (PDD) Data Package
3. Concept Definition Document (CDD) Data Package


5. Test Readiness Review (TRR) Data Package


Project descriptions and deliverables are posted on the projects website:
https://www.colorado.edu/p1198848cc19/.

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

All components purchased from project funds will remain in the ITP 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 coordinator regarding hardware availability and readiness for pickup.

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

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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>NOI</td>
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<td>SPR</td>
<td>Spring Final Review</td>
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Contact Information

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<tr>
<th>Title</th>
<th>Name</th>
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