DEVELOPING PARTNERSHIPS FOR AN UNDERGRADUATE DESIGN PROGRAM ON PLANETARY SCIENCE MISSION CONCEPT DEVELOPMENT . M.P.J. Benfield[1], M.W. Turner[1], P.A. Farrington[1], and B.K. Mitchell[2], [1]The University of Alabama in Huntsville (301 Sparkman Drive, Huntsville, AL 35899), [2]NASA Marshall Space Flight Center (Mail Code FP20, MSFC, AL 35812).

Introduction: The University of Alabama in Huntsville (UAHuntsville) College of Engineering has established a capstone design sequence that provides a real-world design experience for senior engineering students. The Integrated Product Team (IPT) courses are a two-semester design sequence that culminates the coursework of three of our undergraduate engineering degree programs (Mechanical Engineering, Aerospace Engineering, and Industrial and Systems Engineering). Our capstone course has many unique features, including: (a) the project is modeled after NASA's pre-Phase A conceptual design and proposal activity; (b) the project requires the students to participate in multi-disciplinary teams composed of students from different departments/colleges within UAHuntsville; (c) the project requires collaboration with multiple external universities, including international partners; and (d) the project is evaluated by an external review board composed of industry leaders (i.e., NASA, Boeing, etc.) who provide detailed guidance and feedback.

Background: Planetary science mission design involves the complex and iterative collaboration and coordination between a science definition team (SDT) and an engineering design team (EDT). The IPT courses seek to simulate this complicated design process in the classroom by teaming undergraduate science students (who serve as the SDT) with our undergraduate engineering students from UAHuntsville (who serve as the EDT). So, while the undergraduate SDTs are determining the science goals, objectives, and instruments for a certain mission of interest, our undergraduate EDTs are designing the spacecraft(s) to accommodate those instruments and goals. All the students – science and engineering alike – learn that these missions are multifaceted, and that success is not defined as an optimization of a single aspect or subsystem of the mission, but the mission as a whole. Most importantly, the students learn how to communicate their ideas and concepts to people who have backgrounds different from their own. Because of this strong relationship between the science and engineering teams, the missions that we design in the IPT classes always come from the Planetary Science Decadal Survey.

At UAHuntsville, we also benefit from our location – we are located across the street from the Discovery/New Frontiers/Lunar Quest (DNF) Program Office. As such, we are able assemble external, professional, review boards for our students from the DNF personnel. Furthermore, through this avenue, we are able to have Jim Green, Director of the NASA Planetary Science Division, sit on many of our review boards. Our engineering students, as well as our science partners, have greatly benefited from this relationship. Moreover, we get other science and engineering professionals from the local areas, and from around the world, to serve on our review boards. Our external review boards give the students an incredible opportunity to experience the real world while still in the classroom.

Unfortunately, our capstone engineering class is growing faster than our current science partner can support; therefore, we are seeking science partner universities with undergraduate classes to serve as SDTs to our EDTs. Below is our current methodology as well as our expectations for science partners joining our program.

Class Approach: The goal of each IPT project is to develop and design one of the candidate planetary science missions from the Planetary Science Decadal Survey[1]. We require that the candidate mission we are going to design have at least two spacecraft to be developed to to allow us to share work with our university partners. Currently the size of our program dictates that we have the IPT project every semester to accomodate the increased enrollment in engineering. Therefore we have two projects always in development; one in the first semester and one in the second semester. The in-phase project is developed over an academic year (fall and spring semesters) while our out-of-phase project is developed over two academic years (spring and fall semesters). We use the concept reports generated for the Decadal Survey as our guide to developing the initial concept of the mission.

Engineering Design Deliverables and Reviews: The goal of our first semester class is to teach our engineers how to design a planetary science mission. Some, if not all, of our students have never designed a spacecraft before, so we provide an initial semester to allow the students to understand the implications of incorporating science instruments on a spacecraft before they interact too much with the undergraduate SDT.

The first semester has two phases: Misson Design and Element Defintion and Design and Analysis Cycle #1. Using the Decadal Survey concept reports as our guide for an initial science instrument suite, first we have our students go through an exercise on mission design and element definition. The objective is to have the students understand initial mission planning and architecture analysis as well as the allocation of engineering functions to the different spacecraft required for the mission. This phase culminates in the Mission Definition Review where the students select a candidate mission architecture (launch vehicle and spacecraft(s)) that they believe best accommodate the given payload requirements outlined in the Decadel Survey concept report. A study, called the Mission Definition Study, accompanies the review as well. The second half of the first semester is dedicated to developing an initial concept of the chosen spacecraft(s) given the payload requirements from the Decadal Survey concept report. This phase culminates in a Mission Feasibility Review with an accompanying report, the Mission Feasibility Study, which provides our external review board with a description of the proposed spacecraft concept(s) as well as an identification of the key mission risks and issues that must be addressed in the next semester of the project.

The second semester has three phases: Design and Analysis Cycle 1a, 2, and 3 (DAC 1a, 2, and 3). In DAC 1a, the students develop the spacecraft interface requirements for the mission. These requirements are written in the Interface Control Document (ICD) and both university partners must agree to them for the project to move forward. Also during this phase the baseline mission is assessed incorporating the PI-led science payload that is provided by the SDT. This phase culminates in the Delta-Mission Feasibility Review. DAC#2 requires the students to develop more detailed spacecraft that incorporate the specific science payload and operations as defined by the SDT. This phase culminates in the Mission Element Review and the Mission Element Study which outlines the proposed spacecraft solution(s) to accommodate the PI-led science payload and operations. DAC#3 continues to have the students detail the proposed spacecraft concept(s). The Mission Concept Review, much like the one at NASA, culminates this entire design educational experience. Students have to develop their proposed concept and describe both in written form via the Mission Concept Proposal and in oral form via a briefing to the external review board.

Science Defintion Team Expectations: We expect that our science partners will participate with us over the two semesters to provide a similar experience for their science students. During each phase of the engineering design, the science students provide additional input and detail to the science implementation portion of the mission.

Much like the EDT first semester where our engineering students are introduced to planetary science mission design, in the first semester the science students are introduced to the proposed mission concept and research information on the selected planetary body to determine the science goals and objectives that they wish to perform. At the end of the first semester we require a Science Requirements Traceability Matrix (SRTM)[2] and initial science instrument requirements of mass, power, and volume.

In the second semester of the project, the SDT provides a formal list of science priorities as well as all of the instrument requirements. They provide a science payload concept of operations that outlines the frequency, duration, and lifetime of the instrument during the proposed mission. The science team provides sections to the Mission Concept Proposal and the brief at the Misison Concept Review.

Summary: Through its IPT class, The University of Alabama in Huntsville provides a unique and exciting educational experience for its seniors in engineering design. The program continues to expand and needs to identify additional science partners to continue its expansion. Interested professors should contact Dr. Phillip A. Farrington at phillip.farrington@uah.edu or (256) 824-6568.

References: [1] http://sites.nationalacademies.org/SSB/SSB_059331.
[2] Weiss, J.R., Smythe, W.D., Lu, W. “Science Traceability”, IEEEAC paper #2.0402.