AC 2007-2859: USING REGIONAL TECHNICAL CONFERENCES TO AUGMENT AEROSPACE DESIGN PROJECTS

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Abstract

Successfully integrating academic and industry players into the aerospace engineering classroom requires innovation and focus. The benefits, however, include the illustration of current aerospace design practices and tools. This paper describes the co-location of a regional technical symposium alongside a capstone aerospace design project. With this approach, industry has a focused interaction with students and faculty that significantly augments the traditional classroom experience. A case study on a tactical missile project is discussed in detail to illustrate how this benefits the student's ability, "to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability." The symposium described was filmed making it available to use at another time or institution.

Introduction

Learning outcomes for aerospace design students often stress the practical application of student knowledge. For example, aerospace programs are asked to show that students have "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability." Another outcome states that students shall have "an ability to function on multi-disciplinary teams," and "recognition of the need for, and an ability to engage in life-long learning." While faculty can teach these items to a certain degree, industry can enhance the level of these outcomes if ways can be found that effectively allow industry professionals to interact with faculty and students.

The capstone engineering design class at The University of Alabama in Huntsville has experimented with the integration of industry mentors in the classroom for the past 15 years. The mentors have been identified by specific disciplines related to the project, provided one lecture on the topic, and been available to advise the students during the project. Another team of industry mentors also serve the role of "customer" by developing a practical design specification and judging the teams in a design competition.

We have tried several approaches for bringing the industry mentors to the classroom. The first approach was to have one lecture per week in the classroom by each mentor. This worked well, but did not allow the material to be introduced early enough in a one-semester course to be effective. The second approach was to have multiple, simultaneous guest lectures during the first two weeks of class. This helped the schedule issue, but detracted from students orientation in other disciplines and seeing how the disciplines might interact in the design process. This paper presents a third alternative in which a one-day, professional, symposium was held to present and discuss focused topics about the design project. This approach has addressed both the infusion of the material at the beginning of the project and allowed participants a better understanding of the interactions of all the disciplines. Since the symposium was also presented as a professional development opportunity for other professionals in the region it attracts experienced speakers who provide high-quality materials.

Integrated Product Team Project

The Integrated Product Team (IPT) project provides a capstone design experience of aerospace engineering students at The University of Alabama in Huntsville (UAH)[1] and Ecole Superieure des Techniques Aeronautiques et de Construction (ESTACA) a college in France.[2] The objective of the course is to integrate the technical skills learned at the undergraduate level in a design project. The actual project is a "nesting" of several classes. The core students come from the senior-level Aerospace and Mechanical Engineering design classes. The students are grouped into multi-disciplinary teams that also can include electrical, computer, or industrial engineers and English students.[3] Each team member has a designated technical/support role on the team. This allowed individual members to understand their responsibilities, receive training in their area, and gain focused access to external industry mentors.

The IPT project occurs in three phases over the course of one academic semester. In Phase 1, the entire class, guided by industry mentors produces a Baseline Design. The mentors orient each student specialist in their respective discipline. A joint review is held in which a Baseline Design is evaluated against the design specification. In Phase 2, the IPT teams work separately (now in competition) and each team synthesizes three alternatives to the baseline. The teams give individual poster presentations to reviewers and mentors that explain their alternatives and rationale for selecting one of the alternative concepts. In Phase 3, each team completes a conceptual design on their selected concept and produces a fifty page proposal. This proposal and an oral presentation are the basis for the final ranking of the competition.

Case Study – Advanced Tactical Missile Project

The objective of the Advanced Tactical Missile (ATM) system design project was to do a conceptual design of a tactical missile which added range and guidance to the existing Hydra 70 missile.[4] The system requirements include the delivery of a 13-pound warhead to 8 km, an inertial/global-positioning system navigation strategy, compatibility with existing air/ground launchers, and a maximum production cost of $15,000 per unit. The teams produced designs that included an active GPS guidance system, controllable forward canards, detailed propulsion system grain design, and 3-degrees of freedom trajectory analyses. The final design shows that a single-pulse solid rocket with active guidance meets all the system requirements and could exceed the range requirement by 50%.

Participants

Three integrated product teams, composed of sixty undergraduate engineering students competed in the ATM design competition judged by local professionals to develop the designs. The project involved eighteen industry mentors from AMCOM, Snecma, CLERG, Cirrius Technologies, Sigma Services of America, and KPH Research Inc. These people gave lectures at the symposium and served as consultants throughout the project. In addition, twenty-six students from technical editing, marketing, and industrial engineering at The of Alabama in Huntsville worked on related projects.

Regional Technical Symposium

An eight-hour symposium on the design aspects of the course was given in the second week of the project. Planning for the symposium began about six moths before the start of the project. At this juncture, the instructor worked with an industry professional to outline a particular design project along with the technical disciplines that were to be involved in the project. The instructor selected a suitable textbook and student discipline assignments that covered these topics. Table 1 shows the outline of the materials for the ATM project. The instructor then presented a proposal for a one-day symposium to the local American Institute of Aeronautics and Astronautics (AIAA) chapter on the topics. The local AIAA chapter then approved the proposal, advertised the symposium to local professionals, and handled the financial arrangements for the conference. Over forty professionals registered and participated in the course along with the sixty engineering students from our design class.

Table 1. Outline of the Symposium, Book, and Student Responsibilities.

1 – Notional System Requirements		
Symposium Topics	**Book Chapter**	**Student Discipline**
Motivations and Objectives	Introduction	Project Office
Design Specifications	Key Drivers in the Design Process	Project Office
2 – Design Trade Issues		
Symposium Topics	**Book Chapter**	**Student Discipline**
Systems Engineering	Development Process	Systems Engineer
Aerodynamics	Aerodynamic Considerations in Tactical Missile Design	Aerodynamics
Propulsion	Propulsion Considerations in Tactical Missile Design	Propulsion
Trajectory	Flight Performance Considerations in Tactical Missile Design	Trajectory
Avionics	None	Avionics
Structures	Weight Considerations in Tactical Missile Design	Structures
Platform Integration	Measures of Merit and Launch Platform Integration	Platform Integration
3- Baseline Missile and Tools		
Symposium Topics	**Book Chapter**	**Student Discipline**
Grain Design Tool	Sizing Examples	Propulsion
Case Design Tools	Sizing Examples	Structures
Aerodynamic Design Tool	Sizing Examples	Aerodynamics
Baseline Design and Assessment	Summary and Lessons Learned	Systems Engineer

The instructor then recruited experienced speakers in each area to prepare a 25-minute presentation on each topic. The talks were focused on the particular design project at hand. The speakers submitted all the materials six weeks in advance of the symposium so that they could be reviewed for continuity and export control issues by the government.

The symposium was divided into three sessions. In Session One we laid out what we called a notional system requirement. It has been found over the years in teaching that if you give people a particular problem, it helps focus the discussion and helps focus the topics that you choose to talk about. Dr. Jay Lilley from The Army Aviation and Missile Research, Engineering, and Development Center presented a specification for a tactical missile in fairly good detail—the need for it and the specifications. His team presented material that gave a context in which tactical missile issues were discussed. Session Two talked about design trade issues. A number of experts in various discipline areas discussed the various aspects of tactical missile design. These were Systems Engineering, Aerodynamics, Propulsion, Trajectories, Structures, Avionics, and Platform Integration. The final session, Session Three, showed a particular solution to the design requirements outlined in Session One. This was performed by a graduate class at The University of Alabama in HUntsville during the previous semester in conjunction with a 600-level mechanical and aerospace engineering design class. In this session we showed the operation of some very simple first order design codes that were available on the CD-ROM. Some of them were basically spreadsheet type designs that showed the inputs and outputs to make those codes work to match the presentation materials. This structure provided a context for the symposium, showed the general design trade issues in each discipline, and then showed a particular solution to the problem, employing those principles at the end.

The university also provided a two-volume CD-ROM to the students and participants of the talks. The CD-ROMs contained synchronized presentations, charts, biographies, software, and reference materials shown in the symposium. Microsoft Producer™ was used to make the CD-ROM materials that allowed the synchronized playback of the video, sound, and charts. Closed captioning was also added for the hearing impaired. Figure 1 shows what the playback of the material looks like on a computer screen. The last half of the symposium was pre-filmed the week before the symposium. This allowed the first half of the day to be filmed live and the CD-ROM to be produced, burned and provided to the participants at the close of the day. With the material in CD-ROM format, it became portable so that the experience can be repeated in other semesters or schools. There was also a sister symposium in France the semester before this conference. We had the French propulsion industry give about three and a half hours of background on various tactical missile propulsion topics. This material was also included in the CD-ROM.

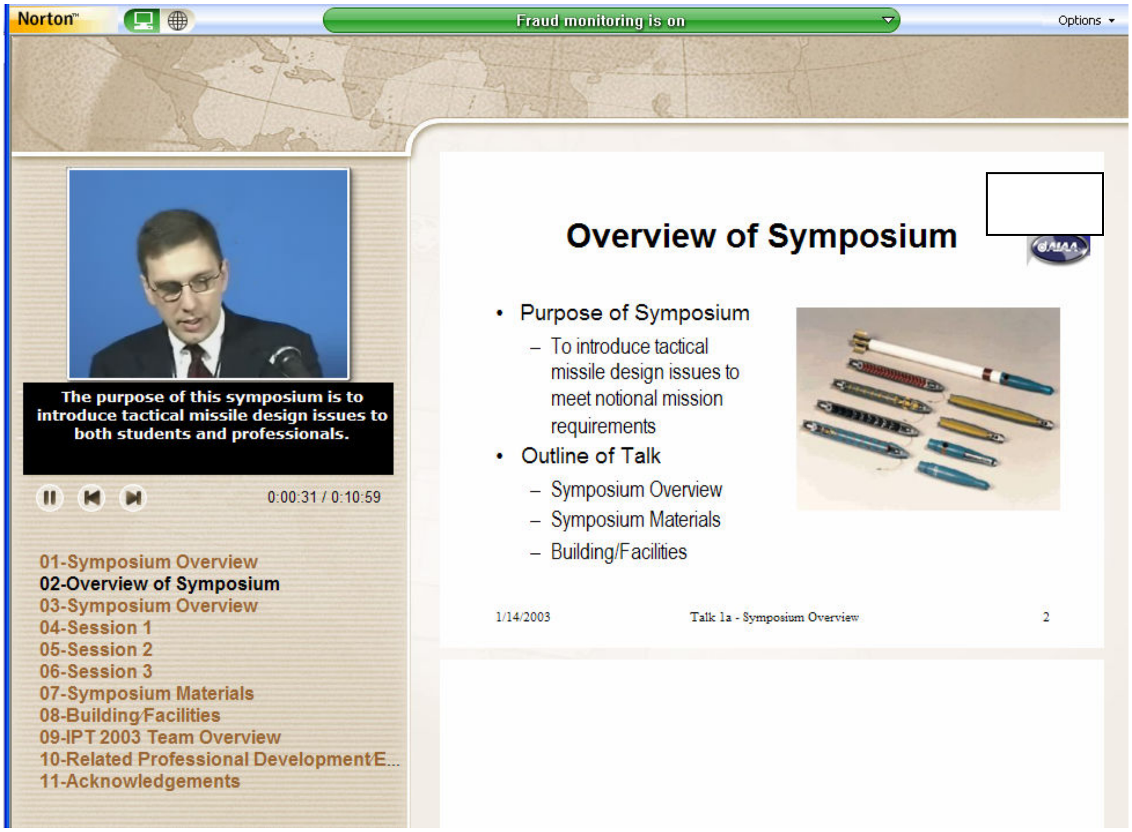

Figure 1. Example Replay Format of Symposium Materials from CD-ROM.

Resulting Improvements in Outcomes

Table 2 shows some of the benefits for having industry professions interact with the students in a symposium. In addition to these, other items are good for the students. They now have an industry contact that they can call on for advice and information. Industry reviewers gave high marks to the quality and coherences of the technical reports and designs produced by the class that participated in the symposium compared with those who had not experienced this.

Final Comments

With some focused planning, a technical symposium can be held that benefits both students and instructors on achieving important learning outcomes. The effort does not have to be for just one semester. Once recorded, the material can be reused for several offerings of the project at different times or different institutions. In fact, the university reused the same material three years later in a graduate missile systems design course. Perhaps such conferences could be held as a part of regional or national design competitions to allow this approach to be shared with multiple universities. Our university has done four of these symposia over the course of four years with similar results.

Table 2. Outcomes from the Symposium

Desired Outcome	Symposium Features
An ability to design a system, component, or process to meet desired needs within realistic constraints	Realistic design constraints developed in conjunction with industry and are then applied to an example design.
such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Mentors explained practical cost constraints for systems and components and the importance of interfacing with current equipment, ease of manufacturing, and field operations.
An ability to function on multi-disciplinary teams.	The symposium illustrated systems engineering and the individual pieces of the design process and then how they fit together by a design example. All disciplines were present and the speakers interacted in the discussion of this topic.
A recognition of the need for, and an ability to engage in life-long learning	Students are co-located with industry professionals who are themselves engaging in lifelong learning.
the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	The current need and use of these weapons on the battlefield was discussed and societal and political implication of improving their accuracy.

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