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PROGRAM OBJECTIVES

Worcester Polytechnic Institute's Advanced Space Design (ASD) Program provides project-based design experiences that combine a highly motivating, need-to-know experience with an integrative capstone design that draws on the know-how of practitioners in the profession. Mechanical engineering students work with their counterparts in electrical, chemical, and civil engineering to develop integrated packages of experiments to be conducted in the micro-gravity environment of space.

WPI CONTEXT

The undergraduate curriculum has several distinguishing characteristics that are shared across all engineering majors. Among these are two significant project-based activities, each of which requires satisfactory completion if the student is to qualify for the bachelor of science degree. One is the *Interactive Qualifying Project (IQP)*, in which students address the interactions between technology and society. The second is the *Major Qualifying Project (MQP)*, the capstone design experience for engineering majors in their respective disciplines. The MQP requires each student to demonstrate the level of proficiency in design associated with the engineering discipline expected by the faculty to be at or above the bachelor's level. Each year some 200 students receive their degrees in mechanical engineering from WPI, of which about 20 will have completed their MQP in the Advanced Space Design Program, while six to twelve will have completed an IQP. It should be noted that each project carries the equivalent credit of three courses, and all ASD projects are completed by mul-

ti-ple-student teams. Thus, the level of effort is quite high and faculty standards for student performance are much different than the usual senior class design experience.

BACKGROUND

The program referred to today as WPI's Center for Advanced Space Design evolved from a series of educational initiatives begun in 1982 in collaboration with engineers and scientists of the MITRE Corporation, through NASA's Get Away Special (GAS) program. The GAS program provides experimental opportunities in a small, self-contained canister (5 cubic foot, 200-pound payload) housed in the cargo bay of the shuttle. The first canister of experiments is scheduled for a 1991 launch. The second set is in the preliminary design phase and is likely to be launched in the 1992-93 school year. The 1991 launch will include experiments in fluid behavior, and zeolite crystal growth. Some 300 students worked on the development of these experiments, the system controls and data acquisition systems, and the support structure and power systems.

The experiments that populate the first of the two canisters in this program are briefly described below.

Fluid Behavior Experiment

Several methods for measuring the behavior of a two-phase fluid system in a low acceleration environment will be tested. Two identical measurement chambers will be used — one containing a "wetting" solution, the other a "non-wetting" solution. The measurement techniques are based on a thermody-

dynamic properties measurement system and an ultrasonic measurement system.

The history of the development of this experiment is representatively detailed below.

Zeolite Crystal Growth Experiment

This experiment will determine whether a low acceleration environment will promote the growth of large zeolite crystals in a small, heated reactor vessel. A liquid growth solution will be brought to the reaction temperature and stabilized at that temperature for three days. An electronic controller will maintain the required temperature, activating a heater coil wrapped around the autoclave when necessary. The entire unit is contained in a super insulated vacuum canister to minimize heat loss and power consumption.

Environmental Data Acquisition System

This module is a completely self-contained data acquisition system for storing data from other experiments and for cataloging the environment internal to the GASCAN from launch to landing. A barometric relay will activate the system during launch. During its operation, data will be stored from the Zeolite experiment, the Micro-Gravity Accelerometer experiment, and the Fluid Behavior experiment. Data will also be stored from several temperature transducers, three high-level accelerometers, gas pressure and sound level transducers, and the battery voltages. All data will be stored on digital cassette tape for post-flight analysis.

Three low-level ($10^{-4}G$) accelerometers in a triaxial arrangement have been integrated with the appropriate instrumentation to capture low-level accelerations.

Experiment Support Structure

For Get Away Special payloads, the engineering support structure (ESS) must efficiently configure the individual experiments within the cylindrical container while meeting all safety specifications. The resulting structure was composed of a tri-wall frame with the battery pack in a hermetically sealed demountable box on one end and an end-plate holding several experiments on the other end.

A finite element analysis of the structure was performed to evaluate its overall strength and to determine the fundamental modes and frequencies of oscillation. The ultimate margin of safety for the

structure is 0.5 while the fundamental frequency of oscillation is 67 hertz, both well above the respective NASA specifications.

Because of the absolute volume and weight constraints NASA imposed on the canister, and because of the counter intuitive environment of space, the program indeed provides a realistic microcosm of tradeoffs, optimization, cost containment, and the need to honor real-world constraints, all while providing an intellectually challenging problem-solving context.

Experiments for the anticipated 1993 launch are in the areas of fluid mechanics, combustion, and atmospheric properties measurement. Each carries with it demanding design constraints, and in the aggregate requires that all the project teams constrain the likely impact of their particular packages on the canister environment.

THE WPI CENTER FOR ADVANCED SPACE DESIGN

The current operation of WPI's ASD Center has grown beyond the MITRE relationship through the support of NASA, the University Space Research Association, and through contributions from corporations. Since its 1982 beginnings, before there were any mechanical engineering majors emphasizing aerospace design (MEA majors), some 150 ME majors have completed MQP's in the program. Today, there are 300 MEA majors registered at WPI and the ASD Center will be called upon to expand its project opportunities significantly. Several faculty research initiatives are complementing the undergraduate project work being advised, master's theses are now being completed, students regularly produce the *Advance Space Design Journal* as a newsletter for the many people who have become involved in the program's varied activities, and IQPs are being conducted on topics related to space treaty development, measures for evaluating space technology and mission impacts, and the commercialization of small satellites.

PROGRAM CHANGES AND IMPACTS

The ASD Program has evolved to a well-structured program of exceptionally high quality design opportunities for undergraduates. The program's most notable impacts have been to create teaching-research linkages for the faculty, while simultaneously providing very significant practitioner interactions for both faculty and students. Critical design reviews, con-

ducted by industry engineers, have proved to be one of the most important features of the program from both an educational and an interaction point of view.

The qualifying project activity demanded by WPI's curriculum is faculty intensive. The ASD Program provides a basis for combining the teaching efforts of the faculty with their research, while maintaining a high-level interaction with practicing professionals in government service and industry. This efficiency of effort has allowed WPI to provide design opportunities of extraordinary quality for a large number of our undergraduate students.