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**Paper Session I-D - Integrating University Space Studies**

**Coursework with the Launch Site Work Environment**

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INTEGRATING UNIVERSITY SPACE STUDIES COURSEWORK WITH THE LAUNCH SITE WORK ENVIRONMENT

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ABSTRACT & INTRODUCTION

This paper describes a new concept in education for the space program at the university level. Under the direction of the University of Central Florida, College of Engineering a program has been developed by the Florida Space Institute to integrate university classroom teaching with the opportunity to experience the "real world" of the space program at the NASA and U. S. Air Force facilities at Cape Canaveral by providing a “Practice Based Education” initiative.

Upper level university courses have been initiated to combine classroom teaching with laboratory periods featuring opportunities for students to interact with the actual engineers, equipment, facilities, and the environment of launch site operations.

The program integrates professors and students from several universities with the experience of engineers from both government and corporate organizations to bring about an innovative approach to producing a space industry workforce with a head start in the engineering workplace environment.

BACKGROUND

In the spring of 1996 the University of Central Florida, together with the Florida space Institute, developed a new concept termed “Practice Based Education” (PBE) which seeks to integrate the university student’s education with an introduction into the real world of space program work activity at the launch site. The methodology was designed to do so not by alternate work and education periods such as a co-operative course of full time work interspersed with full time study. Rather, the PBE approach utilizes the structure of upper level coursework which is configured in the lecture-laboratory approach. This approach allows the student to attend lectures and to experience the lecture material in a laboratory setting so as to enhance the student's learning experience. However, the PBE approach takes this concept a step further and sets the laboratory portion of the course in a launch site work environment.
APPROACH

Unlike traditional laboratory experiences, the courses which utilize the PBE concept are designed to integrate the lecture material with an understanding of how the actual work experience in launch site space program activities makes use of the material studied in the university environment. Also, the work site laboratory experience gives the students an appreciation, not only of the coursework material being studied, but also of how the material studied in their program of courses, both traditional and PBE, is fitted into the structure of the work environment.

Given that the work environment in general, and the launch site environment in particular, reflect such a variety of areas, interfaces, factors, organizations, and activities it is clear that no course can be easily developed to provide a continual exact one-to-one relation of each lecture period with each laboratory period. Nor should it. The approach that has been developed follows in microcosm the approach that we find in our usual transition from education to work practice. That is a strong theoretical foundation in the educational experience followed by real-world learning in the work experience.

To that end, while the courses provide the theoretical basis for the students’ learning, the laboratories are often structured to provide nuts-and-bolts introductions to a variety of work-related activities.

ORGANIZATION

The PBE courses are developed within the structure of the Florida Space Institute under the general supervision of the University of Central Florida, College of Engineering. They are open to upper level students from the University of Central Florida and the Florida Institute of Technology. The lectures are presented primarily by professors from these two institutions. Lecturers are employed by their respective academic institutions and have a background of expertise in the material presented in the lecture phase. Since the lecture material may cover a broad scope of study during each individual course, it is not unusual to have the actual lectures given by several instructors, each of whom covers that material in which he is most knowledgeable.

The PBE course lectures are presented at the launch site which is either the NASA John F. Kennedy Space Center or the U. S. Air Force Cape Canaveral Air Force Station. Course lectures are usually presented in the morning on one day of the week. These sessions are taught as any other university course with approved texts, examinations, projects to be handed in for evaluation, and full credit.

The laboratory sessions of the PBE courses are presented in the afternoons, usually on the same day as the lecture so as to minimize travel. The laboratory sessions are normally presented by full-time space program working personnel who try to bring the student into the work environment for a few hours. The laboratory session structure takes many forms including participation in activities; familiarization with operations and equipment; introduction to spaceflight hardware, including flight hardware, ground support systems, and support facilities. The actual structure of the laboratory session and the topics to be covered are developed by the academic representative and the work site personnel.
INSTITUTIONAL COOPERATION

The PBE approach is dependent on a cooperative effort between academic and work site institutions. The University of Central Florida has been the primary academic institution establishing the PBE approach. The initial work site institution was Boeing Aerospace Operations, Inc. at the Cape Canaveral Air Force Station. Boeing Aerospace Operations, Inc., together with the support of the United States Air Force, worked with the program in the spring of 1996 in the development and the presentation of the first course. In the fall of that year the NASA John F. Kennedy Space Center cooperated in the presentation of several such courses. These organizations have continued their work with this program and currently are cooperating in the presentation of coursework and the planning for future courses.

Obviously it is vital that a cooperative environment between the academic and work site organizations exist if the courses are to succeed. It is also vital that the higher levels of the work site organization management structures be supportive. Both Boeing Aerospace Operations and the John F. Kennedy Space Center have strong commitments to the community in general and to the educational community in particular. Both the Boeing Aerospace Operations Eastern Launch Site Director and the NASA John F. Kennedy Space Center Director provided support and encouragement in these efforts.

At lower levels of the organization structures, both Boeing Aerospace Operations, Inc. and the John F. Kennedy Space Center provided personnel to plan and conduct the laboratory sessions of these courses. The working-level personnel who help plan, develop, and present the laboratory sessions have been enthusiastic participants and have enjoyed the opportunity to interact with the students during these courses.

In addition to the above organizations, individual course sessions have been held with the assistance of personnel from many organizations which were engaged in operations at the launch site such as the German Space Agency, Spacehab, Inc., the Space Vacuum Epitaxy Center, Jet Propulsion Laboratory, etc.

PBE COURSE HISTORY

As of the winter-spring of 1997 there have been a total of seven courses presented in this program. These include the following:

Spring 1996: Processing Space Launch Systems

Fall 1996: Processing Space Launch Systems
Materials Performance in Space Applications
Small Satellite/Payload Integration and Mission Analysis
Telemetry & Space Computer Systems

Winter 1997: Processing Space Launch Systems
Telemetry and Space Computer Systems
Small Satellite/Payload Integration and Mission Analysis.

Individual descriptions of these courses are presented in the following section.
COURSE DESCRIPTIONS

PROCESSING SPACE LAUNCH SYSTEMS:

This course was an interdisciplinary course structured around the preparation and checkout of the Boeing Inertial Upper Stage (IUS). The IUS is used as an upperstage for the Titan launch vehicle and is also used as a booster stage for payloads deployed from the Space Shuttle. An interdisciplinary group of engineering students are involved in taking this course. The course requires the students to collectively integrate their knowledge of mechanical systems, computer systems, operational systems, and human interactions in the performance of complex tasks. The course uses the IUS, its facilities, and its launch site team as an instructional aid in presenting the material. Although the IUS is the subject of the laboratory sessions, both academic and IUS personnel plan these sessions such that no hazard to flight hardware or to personnel are present. Students are not permitted to take part in hazardous operations nor to be present when such operations are conducted.

Prerequisites for computer engineering students include Computer Systems Design and Introduction to computer Engineering; required for industrial engineering students is Systems Simulation; for electrical engineering students is Signal Analysis & Communication; and for mechanical engineering students Junior Aerospace Laboratory and Measurements.

The course text is Space Mission Analysis and Design BY j. Wertz and Wiley Larson.

Typical lecture material for the course included an introductory session on ethics and requirements and processing; followed by sessions on propulsion, structures and mechanisms, thermal control, telemetry, guidance and control, navigation, power systems, ordinance, interfaces, software and computers, and on system upgrades.

Laboratory activities have included sessions on facility safety, flight hardware protections, clean room operations, facility familiarization, flight hardware component deployment/extension, checkout station familiarization, guidance and flight control system system familiarization, battery laboratory operations, launch vehicle familiarization, inert ordnance device familiarization, and telemetry operations.

Individual and team projects are included to help the student understand the material which is presented and to integrate the material into a cohesive learning experience.

SMALL SATELLITE/PAYLOAD INTEGRATION AND MISSION ANALYSIS

This course was developed to evaluate the impact of integration and design concepts on various satellite and attached payload component subsystems into payload final configurations. An interdisciplinary group of upper level students experience the actual payload processing environment and interact with engineers who are engaged in the preflight assembly, payload-integration, test, checkout, launch vehicle-integration and launch of small payloads at the Kennedy Space Center and the cape Canaveral Air Force Station. Students learn system requirements for small spacecraft, analysis of satellite subsystems, and learn to create design options for system requirements.
Prerequisites for computer engineering students include Computer Systems design and Introduction to Computer Engineering; required for industrial engineering students is Systems Simulation; for electrical engineering students is Signal Analysis and communication; and for mechanical engineering students are Junior Aerospace laboratory and Measurement.

The text for this course is also Space Vehicle Design by M. Griffin and J. French.

Lecture material sessions include mission characterization, space mission geometry, introduction to astrodynamics, orbital analysis, space environment/survivability, payload definition and sizing, spacecraft design, guidance, and control, navigation, communications, command, data handling, antennas, thermal control, structures and mechanisms, propulsion, and low cost design.

Laboratory sessions have included Space Shuttle processing familiarization, Space Shuttle processing facilities familiarization, introduction to Space Shuttle launch facilities, Shuttle Launch Control Center operations, Spacelab processing operations, Space Stations processing operations, ORFEUS-SPAS payload familiarization, Wake Shield Facility-3 familiarization, Operations and checkout building test operations, Mars Global Surveyor and Mars Pathfinder interplanetary payload test operations familiarization, experiment testing for the Materials Science Laboratory Spacelab payload, SPACEHAB processing operations, and expendable launch vehicle ground data station operations.

The development and presentation of individual projects was also a feature of this course.

MATERIALS PERFORMANCE IN SPACE APPLICATIONS

This course provides an interdisciplinary group of engineering students with training in the special requirements for materials used in space flight hardware. This includes characterization and evaluation of their performance and failure analysis of components which have actually failed both in prelaunch processing operations as well as actual space flight. The course laboratory sessions include the active support of the John F. Kennedy Space Center’s Materials Science Division laboratories.

Prerequisites include Property Relationship of Materials, Statics, and Strength of Materials

The text materials for the course are included in class handouts

Lecture material included safety, metrology (fuse and valve), scanning electron microscopy, energy dispersive spectroscopy, thermal characterization, electrical characterization, fuse failure analysis, leak detection, mechanical characterization, chemical analysis, solenoid characterization, valve failure analysis, principles of failure analysis, space applications of materials.

Laboratory sessions included facilities and equipment familiarization, analysis by photography, microscopy, and radiography, scanning electron microscope operations, energy dispersive spectroscopy operations, cryogenic test operations, electrical testing, pressure testing, breakaway torque analysis, and infrared spectroscopy.

Students were engaged in actual failure analysis problems.
TELEMETRY AND SPACE COMPUTER SYSTEMS

The course utilized the Boeing IUS computer and telemetry systems as an educational basis for an interdisciplinary group of students. The course provides an understanding of how computers and communications theory concepts are used in the actual telemetry of space launch vehicles, payloads, and satellites.

Prerequisites for computer engineering students included Electrical Networks and Introduction to Computer Engineering; for mechanical engineering students were Junior Aerospace laboratory; industrial engineering students required Systems Simulation; and Signal Analysis and Communication was required for electrical engineering students.

The textbooks used in this course are Telemetry Systems Design by F. Carden; and Space Mission Analysis and Design by J. Wetz and W. Larson.

Lecture sessions include telemetry systems and IRIG standards, modulation techniques, detection and noise, antennas, RF systems and grounding techniques, telemetry link design, space computers and computerized ground support, digital architecture and digital interface, digital to analog conversion and analog to digital conversion, and data formats.

OBSERVATIONS AND LESSONS

During the initial series of the programs courses it was noted that the space program organizations which were acting as laboratory providers could also benefit by the interaction with the university personnel. In at least one instance the inspection of an area of the IUS which was extremely difficult to access was facilitated by a device one of the university personnel was familiar with. This provided an easier way to do a difficult job. It was also noted that the student’s experience in the real world of space program operations during the course was cited as a positive factor in employment by corporate personnel. Subjective student assessments of their experiences has been generally positive and the courses have tended to have more applicants than spaces available for them. An additional finding was that the students had a chance to become familiar with the values of the space program work environment in a way not possible through normal news media, technical journalism, or university coursework methods.

One of the lessons learned from this period has been that a complete planning effort early enough to facilitate the individual course laboratory sessions is of great benefit. Due to the variety of launch site personnel and variety of laboratory topics early planning makes for a smoother operation.

An additional lesson is that the laboratory sessions need to be planned with flexibility in mind when they are keyed to specific launch site operations due to the changeable nature of launches and launch site schedules.
In summary then; work Practice Based Education provides an effective way to introduce the student in the university upper level class environment to the launch site work environment. Obviously, analysis of additional areas of the launch site work environment is desirable to assess their suitability for inclusion in such a program.

Perhaps less obviously, but nevertheless worth considering, is the applicability of Practice Based Education coursework in other work site environments and in other fields. The marriage of the lecture hall and work site may be one which could produce an extended educational resource that would benefit not only the universities and the students, but the corporate and government organizations who are the potential employers of these students.