A

FIVE-YEAR

PLAN

FOR THE

UNDERGRADUATE LABORATORIES

OF THE

SCHOOL OF AEROSPACE ENGINEERING

GEORGIA INSTITUTE OF TECHNOLOGY

January 2002

OVERVIEW OF LABORATORY PLAN

Introduction

The undergraduate curriculum in Aerospace Engineering is designed to provide a comprehensive program of study leading to a Bachelor's Degree. A key part of this program is the laboratory experience, which is carefully designed to complement the concepts studied in the classroom and to introduce the student to a variety of experimental techniques and modern instrumentation.

The Laboratory Plan begins with a statement of overall goals for the undergraduate laboratories and the place of the laboratories in the curriculum, and then speaks to several items that are common to all of the laboratories. Detailed plans for each undergraduate laboratory as well as for the undergraduate classrooms follow.

Goals of the Undergraduate Laboratories

The goals of the undergraduate laboratories in aerospace engineering are to provide the student with::

a) *A sound education in the fundamentals of experimental methods, diagnostics, and advanced instrumentation.*

b) *A laboratory experience that emphasizes a highly personal and hands-on involvement with challenging experiments, and a chance to learn through measurement and inference.*

c) *Physical insights into the subject matter encountered in the classroom.*

d) *Experimentally-derived results that can be compared with theoretical predictions discussed in the classroom, thus developing in the student a strong feeling and appreciation for the need to continually compare theory with observations.*

e) *An opportunity to make technical presentations technical presentations (written and oral) and respond to questions.*

The Role of the Laboratories in the Curriculum

The laboratory portion of the program of study is designed around the following courses:

a) *Required laboratory courses in the three fundamental disciplines which are the focus of the undergraduate aerospace curriculum, namely aerodynamics, flight mechanics, and structures.*

b) *A computer course and computer applications laboratory which support all of the other laboratory and lecture courses in the curriculum.*

The laboratory courses consist of:

- **AE 3051 - Experimental Fluid Mechanics**. *The course complements AE 2020 (Low Speed Aerodynamics), AE 3450 (Thermodynamics and Compressible Flow) and AE 3021 (High-Speed Aerodynamics).*

- **AE 3145 - Structures Laboratory**. *This course complements AE 2120 (Introduction to Mechanics), AE 3120 (Introduction to Structural Analysis) and AE 3121 (Aerospace Structural Analysis)*

- **AE 4525 -Control System Design Laboratory**. *This course complements AE 3515 and AE 3521 (Aircraft and Spacecraft Flight Dynamics).*

- **COE 1361 – Computing for Engineers.** *This course supports all laboratory and lecture courses in the curriculum.*

In addition, the Aerospace Computer Lab is a facility that supports all laboratory and lecture courses in the AE curriculum by providing students access to modern computational resources for performing class assignments and projects, writing reports and preparing presentations.

Funding and Support for Laboratories

Funding for laboratory equipment comes from the Institute, the School, and from outside sources. The School also supports the laboratories through monies for supplies and personal services. Personal services take the form of Graduate Teaching Assistants (GTAs) and support personnel. Two to three Teaching Assistants are assigned to each of the three experimental laboratories; they set up the experiments, assist/oversee the student experimenters and help in grading laboratory reports, all under faculty supervision. Support personnel include full-time employees in the AE machine shop and AE electronics shop, and computer support specialists. The School policy is that maintenance and repair of instructional laboratory equipment has the first call on the services of the support personnel.

Funding for major equipment items purchased in the past has come primarily from the Institute through the Dean of Engineering, the Provost's Office (Academic Affairs), and Student Technology Fees, as well as some funding from the AE School. It is anticipated that funding support will continue to come from these sources, while outside support from both government (e.g., NSF) and industry will continue to be pursued.

Implementation of the Plan

The plan, as will be detailed, involves continuous upgrade and modernization of laboratory equipment and facilities. It is anticipated that the AE School will continue to receive strong support from the Dean of Engineering in this regard. Meanwhile, outside sources who can aid in equipment needs will be investigated. An instructional laboratory supply budget will be set up as a line item in the school budget to ensure that the necessary supplies will be available as needed. Recently (in late 2001) funds from the Capital Campaign related to Endowed Chairs were identified as a possible source for some of the maintenance and refurbishment issues facing undergraduate laboratories. Each year, the School's faculty submit competitive proposals to the

Institute's Technology Fee allotment program in order to acquire equipment related to undergraduate instruction. Additional equipment implies additional floor space. Laboratory floor space in the Savant Building across the street from the Guggenheim building was replaced with space in the Weber building across the street from the Montgomery Knight Building in the past year.

Implementation of the laboratory plan also will require technician assistance, both for the ordering and stocking of supplies and for supporting the facilities and the data acquisition software. This need has been recognized in the long-range plan of the AE School; and planning is under way in this regard.

Monitoring the Plan

The day-to-day operation of each laboratory course rests with the faculty member who has been assigned to teach that particular course in a given semester. The faculty coordinators for each course constitute an *ad hoc* Committee for Laboratory Instruction to coordinate instructional laboratory activities. The Committee meets each term with the Chair to review and monitor the laboratory plan.

Detailed Planning

The detailed five-year plan presented in the following sections is a unified plan with five parts describing the three laboratory courses, the computer course, and classroom support. The individual plans have been prepared by the following Aerospace Engineering faculty members, who are currently the sole or joint coordinators for these courses:

Aerodynamics and Propulsion Laboratory	Dr. J. Seizman, Associate Professor Dr. N.M. Komerath, Professor
Flight Mechanic & Controls Laboratory	Dr. JVR Prasad., Professor Dr. P. Tsiotras, Associate Professor
Aerospace Structures Laboratory	Dr. S. Dancila, Assistant Professor
Aerospace Computer Laboratory	Dr. J. I. Craig, Professor Dr. M.J. Smith, Assistant Professor
Classroom Facilities	Dr. J. I. Craig, Professor

Each plan will outline the theme or educational purpose of the particular laboratory course, provide the current status of the laboratory, present the goals and objectives for the next five years, and close with a plan for reaching those goals and objectives. A general summary concludes the overall plan.

Aerodynamics and Propulsion Laboratory Facilities

The laboratory experience in Aerodynamics/Propulsion consists of a 2-credit-hour junior-level Core course (AE3051), aimed to introduce the student to various diagnosticand measurement techniques commonly used in Fluid Mechanics research, preliminary design, and testing, specifically related to aerodynamics and propulsion. Specific goals of AE3051 are to

a) provide students a "hands-on" experience with concepts taught in the aerodynamics/fluids courses;

b) teach experimental methods and techniques employed for flow measurements;

c) help develop effective communication skills, in both written and oral form.

Low-speed aerodynamics (AE2020) is a pre-requisite. Thermodynamics and 2-dimensional compressible flow (AE3450) is a co-requisite. Each laboratory experience is built around an experiment that focuses on a specific aerodynamic or propulsion concept and a series of related measurement techniques. Thus, the student is exposed to a new measurement approach and learns to compare experimental results with the knowledge covered in the lecture courses. There are nine experiments in AE3051, and one experimental design project. Seven of the nine experiments require results summarized into written data reports, and the other two require full laboratory reports. The experiments are performed in teams of three to five students, but the written reports are prepared independently by each student. The reports include the student's answers to several questions that are changed each semester. The grading of the reports considers various aspects of technical reporting and laboratory practice. The experimental design project in an individual effort, and the result are reported orally. Each student makes a 10-minute presentation to the class, describing the proposed solution to a hypothetical measurement problem assigned in the last four weeks of the semester. This "proposal" is evaluated based on the creativity of the approach, the understanding of the underlying fluid mechanical and experimental issues, and the thoroughness of the plan. The presentation is evaluated on its organization and clarity. The audience (students, GTAs, and faculty) is encouraged to ask questions. The data acquisition procedures are largely computerized and all laboratory reports must be produced using word processing and computer graphics. However, some aspects of the experiments are left to be done by human observation, careful alignment and adjustment, judgment and qualitative sketches.

Laboratories

The facilities required to run AE3051 are located in Rooms 403/5 and 106 of the main Aerospace Engineering building, and in the open lab area of the new Propulsion/Combustion Laboratory, which is situated a short distance from the main AE building. Three experiments take place in room 106, which houses the 42"×42" low speed wind tunnel and a shock tube. The supersonic flow experiments are carried out in a Mach 2 tunnel and an in-draft nozzle located in the Propulsion/Combustion Laboratory. The rest of the experiments take place in Room 403/405 (a double bay size room). In all three facilities, the undergraduate labs and courses are assigned top priority in scheduling.

List of Experiments

Nine different sets of experiments are performed in AE 3051 during stretching over eleven weeks of the semester, with the remainder of time devoted to the experimental design project. The titles of the laboratory experiments currently in place are:

1. Force Measurement in a Subsonic Wind Tunnel
2. Pressure Measurement in a Subsonic Wind Tunnel
3. Flow Visualization
4. Digital Sampling of Time-Dependent Signals
5. Unsteady Velocity Measurements in a Jet Using a Hot-Wire Anemometer
6. Velocity Measurements in a Subsonic Flow Using a Laser Doppler Velocimeter
7. Measurements in Unsteady Combustion
8. Transient Measurements in a Shock Tube
9. Optical/Pressure Measurements in a Supersonic Flow

Aerodynamics/Propulsion Labs – Action on Past 5-year Goals

Action Item	Action Item Proposed	Action
1	Renovate the 42" wind tunnel	Using a series of graduate projects, the tunnel has been upgraded with a more powerful motor, fan and a frequency-controlled drive system, replacing the prior motor, fan and analog control system. The turbulence in the tunnel has been steadily reduced through diagnostics and passive-flow-control efforts. These efforts continue, with the turbulence level now lower than it was before incorporation of the new motor.
2	*Refurbish the smoke tunnel to incorporate better lighting and flow-control facilities*	This has been accomplished.
3	*Acquire a capability to use Pressure Sensitive Paints in aerodynamic measurements*	This objective was not met – the associated high-speed flow experiment was judged to be a lower priority.
4	*Expand the planar velocimetry capabilities into a routine undergraduate experiment*	This objective was not met. It was replaced by increased attention to digital signal processing techniques.
5	*Incorporate feedback control experiments into the aerodynamics laboratory*	A new data acquisition/ control system has been acquired and put in place in the Low Turbulence Laboratory. The goal of combining aerodynamics – flight controls experiments was abandoned in view of the change in direction of the Flight Controls Lab (towards more Space-related content – see Controls Lab Plan)
6	*Enable capture of*	Video/digital cameras are used to enable capture of such

	short-time-scale events in the combustion and supersonic flow experiments	events in these experiments.
7	*Leverage elective lab courses*	Elective laboratory courses in fluid dynamics/ aerodynamics have not been offered since the beginning of the semester curriculum – interested undergraduates are allowed to take the graduate Flow Diagnostics and Flow Controls course, AE6052.
Other changes implemented:		
	Upgrade data acquisition	Most of the experiments have been upgraded (hardware and software) and use consistent LabView™ virtual interfaces.
	Piezoresisitve pressure sensors	The operation and use of mercury manometers was replaced with piezoresistive pressure transducers to modernize the course material and reduce a potential safety hazard.
	Digital sampling and frequency analysis	A new lab was added to introduce students to the concepts of digital sampling, and reconstruction of time-series data. The lab also covers the topics of frequency analysis (Fourier analysis, FFTs), which is now incorporated in the the turbulence and combustion experiments.
	Uncertainty and error analysis	Lecture material is now presented on uncertainty analysis for experimental data, and uncertainty analysis is required on the two full reports.
	Renovate shock tube	The facility for filling shock tube driver section and depressurizing driven section, and the flange system connecting the two were redesigned and completely rebuilt in order to improve the shock tube reliability, and the maximum pressure ratio achieveable.
	Web-based lab manual	The lab manuals were rewritten and are now on-line, located on a course web-site www.ae.gatech.edu/classes/ae3051 (along with all course information, including experimental data which is posted there after it is acquired).

Goals and Objectives for Next Five Years

The goals for improving the undergraduate fluid mechanics laboratories over the next 5 years are:

1. Incorporate web-based prelab modules: to ensure students are better prepared before they perform the experimental measurements.
2. Enhance the flow visualization lab.
3. Add a new propulsion experiment.

Plan for Reaching Goals and Objectives

1.Replace or modify the current hydrogen bubble experiments in the water table, most likely option is to use a a planar laser technique. The laser used for the LDV measurements could be used for visualization of a scattering agent added to the water table, which will also require *optical access modifications. A second option is to acquire a small Nd:YAG laser for visualization of fluorescing water dyes or for particle scattering in the small wind tunnel.*

2. *Need to design and implement new experiment incorporating propulsion topics, e.g., thrust, turbomachinery. Will seek equipment funds from the sources indicated at the beginning.*

Flight Mechanics and Controls Laboratory Facilities

The undergraduate controls laboratory is the main avenue for teaching analysis, modeling and control of dynamical (mechanical) systems to the undergaduate students in the School of Aerospace Engineering at GIT. Typically, 90-100 undergraduate students are required to take this lab every year. The pre-requisites include AE3521 (Aircraft and Spacecraft Flight Dynamics) and AE3520 (Vibrations ad System Dynamics). Before the recent conversion to semesters, the undergraduate controls lab was offered as a separate course (under the designation AE3510). The main prerequisite for taking this lab course was AE3501 (Aircraft Flight Control) that taught the students the basic theoretical ideas behind feedback control systems. With the conversion to semesters, AE3501 and AE3510 were combined to one course (AE4520). Therefore, in the current format the students learn the theory and implement it during one semester. This gives the opportunity to the students to reinforce the learned material. In addition, it offers a more complete picture of the students' progress to the instructor, who is now responsible both for the theoretical lectures and the experiments. That was not the case under the AE3501/AE3510 sequence, where often different instructors were responsible for the two courses.

Current Status

The Flight Mechanics and Control laboratory is located on the second floor of the Aerospace Engineering building. The AE4520 course has been offered under the new format since the Spring semester 2000. The response from the students has been mixed. Although they appreciated the integration between the theoretical lectures and experiments, they all too often complained that the experimental part of the course has been passive with little freedom for trial-and-error. In addition, it turned out that the experimental part of the AE4520 was not helpful since the students had difficulty with the theory. As a response, two steps have been taken

1) The AE3520/AE4520 sequence has been replaced by the sequence AE3515/AE4525. AE3515 replaces AE3520 and the theory portion of AE4520. AE4525 is a 2 credit lab (only) course focusing on experimental controls. AE3515 is a pre-requisite to AE4525. It is believed that this separation will reinforce the dynamics and control concepts learned in AE3515 and the flight dynamics concepts learned in AE3521. Also, a significant component of the AE4525 lab course includes flight controller design experiments using the MATLAB and SIMULINK environment.

2) The laboratory experiments have been re-designed to allow real-time execution.This was achieved by acquiring new, state-of-the-art hardware and software that provides the opportunity for more interaction and a more active participation of the students during the experiments.

List of Experiments

The outline of the proposed experiments in AE4802 is given below:

Lab 1: Example problems in the use of MATLAB and SIMULINK
Lab 2: DC motor
Lab 3: DC servo motor
Lab 4: Torsional pendulum experiment
Lab 5: Torsional pendulum experiment
Lab 6: Helicopter experiment
Lab 7: Inverted pendulum experiment
Lab 8: Gyro Stabilized Platform experiment
Lab 9: : Horizontal and Vertical Tail Sizing (MATLAB based)
Lab 10: Longitudinal SAS Design and Evaluation (MATLAB and SIMULINK based)
Lab 11: Longitudinal SCAS Design and Evaluation (MATLAB and SIMULINK based)
Lab 12: Lateral SAS Design and Evaluation (MATLAB and SIMULINK based)
Lab 13: Lateral SCAS Design and Evaluation (MATLAB and SIMULINK based)
Lab 14: Summary , make-up of any missed experiments

Description of New Software/Hardware

Following is the list of changes for Controls lab

1) All four lab computers have been replaced by new computers with faster CPU and more RAM mem and HD space. The operating system in all computers has been upgraded to Win2000. This was necessary in order to be able to run the new real-time kernel for the experiments as well as the new version of MATLAB recently released by Mathworks.
2) A new CMG experiment has been purchased that replaced the old, unreliable CMG experiment. The new experiment was purchased from Educational Control Products and includes:

   - DSP Board (40MHz PMAC by Delta Tau)
   - New Control Amplifier Box (Model 250 Control Box)
   - ECP PC based Student Software (ECP Controls and Dynamics Software for Windows)

3) All four computers have been equipped with digital I/O boards (PC104-MulltiQ-XE Acquisition Board to allow real-time interface with the experiments

4) All computers have been equipped with WinCon, a software from Quanser Consulting that allows real-time implementation of control algorithms.

Schedule: AE4525 will be offered for the first time during the Spring semester of 2002.

Action Items from the Past 5 year-Plan

More aerospace vehicle hardware was to be integrated into these laboratory experiments. Other plans included expanding aircraft-related experiments.

Actions taken

The helicopter experiment, tail sizing experiment, and spacecraft experiments, combining analysis and hardware, address this issue. The fixed-wing aircraft experiment proposed under the past 5-year plan was replaced with spacecraft-related experiments to reflect the need for expanded spacecraft-related content, driven by changes in the aerospace industry and marketplace.

Goals for the next five years

The AE4525 course is at present in its experimental stage.. This course will be refined through assessment and iterations over the next 3 years, starting with the plans outlined above.

Plan for Reaching Goals and Objectives

Assessment of the experimental course over the next 2 years will be used to refine this course and this manner of integrating analysis and experiment into the same lab course.

Aerospace Structures Laboratory

The aerospace structures laboratory provides hands-on experience in structural testing and experimental data collection and analysis for every AE undergraduate. The structures laboratory is currently taught as one course, AE 3145, offered each semester of the academic year. This one-credit hour class is offered in three or four sections each semester, with enrollment in each section limited to 12 students. The course consists of seven two-week laboratory experiment cycles, with a one-hour lecture offered during the first week and a three-hour laboratory performed the following week of each cycle.

This laboratory course is formulated each semester by selecting 7 experiments from the list below. This list changes as new experiments are designed and developed. Training is provided to allow each student to install strain gages in at least one of these experiments. Tests are conducted, data collected, and formal written reports prepared for each experiment. Where applicable, experimental findings are compared with predictions from design theory. Analysis of the data and data visualization are carried out using spreadsheets and Matlab scripts, while reports are prepared using word processors. The use of CAD for drawings is encouraged but not required, since preparatory CAD courses are not a prerequisite for these laboratory courses. The subjects covered by the experimental projects currently available are:

1. Dimensional Measurement and Uncertainty Analysis; Transducer Calibration
2. Strain Gage Applications; Wheatstone Bridge
3. Elastic-Plastic Tensile Test
4. Rosette Strain Gage Use; Stress and Strain Transformation; Symmetric Beam Bending
5. Asymmetric Beam Bending
6. Column Buckling; Southwell Plots
7. Wagner Beam Behavior
8. Space Truss Behavior
9. Plate with a Hole in Uniform Tension
10. Lateral Instability of a Deep Beam
11. Flat Plate Bending
12. Torsional Rigidity
13. Active Material Actuators

Current Status

The AE 3145 course is carefully designed to enhance what is learned in the following courses:

AE 2120 - Introduction to Mechanics
AE 3120 – Introduction to Structural Analysis
AE 3121 – Aerospace Structural Analysis

Space for the Undergraduate Structures Laboratory is located in Room 301 of the Montgomery Knight building. In addition, space is shared with the Structures and Materials Laboratory in

Room 106 of the Montgomery Knight building, and the Composites Manufacturing Laboratory, located in Rooms 216- 217 of the Weber building.

A member of the faculty teaches the laboratory course for a full year. Two Graduate Teaching Assistants are assigned to assist students in each laboratory section. One Instron screw-jack testing machine with modern computer-based controller is available in Room 301 for structural testing, and a second Instron 8500 series servohydraulic test machine, also computer controlled, is available in the Structures and Materials Lab. Thus, both static testing with controlled screw-jack displacements and full dynamic testing under either load, displacement or strain control can be experienced. The laboratory is also equipped with a computerized data acquisition system, and emphasis is placed on the use of this system by the students to automate data collection from the experiments whenever possible. This is part of a joint effort with the Aerodynamics Laboratory (AE3051) to develop and implement a unified treatment of computerized data acquisition and control in tests using advanced instrumentation.

The facilities of the Undergraduate Structures Laboratory have been upgraded over the past 5 years. Through Technology Fee Equipment Grant funding, the electro-mechanical Instron testing machine located in the Undergraduate Structures Laboratory has been upgraded with a modern digital controller and a computer with test control software. Using the same funding source the Instron 8500 servohydraulic test system in the Structures and Materials Lab has been upgraded with a more capable digital controller and with a computer and test control software. This system, acquired primarily to support the instructional laboratories, is shared with the graduate research program and is located in the Structures and Materials Laboratory for convenient access to hydraulic power supply systems.

A major strength of the structures laboratory program is the fact that several professors on the faculty have experimental structures backgrounds and have taught the structures laboratory courses in various forms for the past twenty years. During this period, over 20 different experiments have been designed and developed which provide participatory training in structural testing for each student. These experiments provide verification of design theory taught in several courses in the structures curriculum. The experiments are also designed to develop certain skills, such as:

- use of precision calipers and micrometers
- selection and installation of strain gages and strain gage rosettes
- calibration of deflectometers and load cells
- use of strain gage indicators, wheatstone bridges, and associated circuitry
- operation of the Instron mechanical testing machine
- testing using the Instron 8500 servohydraulic test machine
- data acquisition and control using a PC and LabVIEW

The structures laboratory courses provide a laboratory experience with a student/instructor ratio of about 4/1.

Actions Taken on Items from Past 5 Year Plan
The controller of the electro-mechanical Instron testing machine has been upgraded as planned. The servo-hydraulic Instron testing machine has been included in current AE 3145 experiments and its controller has been upgraded as well. The number of work station has not been increased.

Structures Labs Goals and Objectives for Next Five Years
A biaxial, digital controller equipped, tension-torsion Instron testing machine with computer and test software is a recent hardware addition to the Structures and Materials Laboratory. A set of experiments that utilize this new capability will be developed and included in the experiment list.

The acquisition of a table-top electromechanical testing machine with digital controller and computer user interface is planned. This will expand the existing range of testing capabilities and will allow individual experiments to be conducted in parallel by separate student groups. A replacement of equipment items that are worn and/or not functional is necessary and will be undertaken in the near future.

A new elective undergraduate course, focused on the design of experiments, is planned. This course will offer interested undergraduate students an opportunity to develop their experimental skills and knowledge beyond the level of the material currently covered in AE 3145.

Plan for Reaching Goals and Objectives
Funding from the Technology Fee will be sought, in conjunction with internal funding, to provide for the planned equipment upgrade. The possibility of obtaining equipment through donations from sponsors will also be explored.

Aerospace Computer Laboratory

General

The Aerospace Engineering undergraduate curriculum is designed to make extensive use of personal computers, and a strong emphasis is placed on the use of computers for engineering problem-solving and not merely for abstract "programming" exercises. This use is assumed to begin with the students' own computers and it extends into the classroom and into the instructional laboratories where many experiments are computer-controlled and data is acquired directly into computers. Students are expected to learn to routinely simulate and analyze engineering systems, acquire and process experimental data, design and synthesize aerospace systems, and present problem solutions in peer review settings using personal computers and appropriate audio/visual (A/V) facilities. Laboratory and project reports are required to be computer-prepared (either printed or submitted electronically), and presentations are made using contemporary A/V equipment.

A new introductory course in computing for engineers (COE 1361) developed by faculty in the College of Engineering in 2001, focuses on the basic problem-solving tools that will be used throughout the undergraduate program of study. The course is being offered on a limited experimental basis during the current academic year to assess instructional methods and course content, and it is anticipated that the course will become the required first computing course for a majority of Schools in the College of Engineering. During the 2001-2 academic year it is being taught using several computing labs on the campus including the Aerospace Computer Laboratory. All of the instruction in this course is held in the Lab, and the students follow the lecture and carry out programming exercises during the class. It is expected that homework and additional exercises will be carried out by the students on their own computers.

To varying degrees, each of the core courses in the AE undergraduate program also makes use of the Laboratory for computational analysis, simulation, visualization, data processing, etc., using both commercial software and custom prepared software. The AE elective courses which offer the opportunity to explore other advanced topics such as computational fluid dynamics, finite element analysis, and avionics also make use of this laboratory.

The undergraduate instructional laboratories all include computational facilities built around personal computers. Generally, these systems are designed and configured to run specialized software associated with the particular lab, and they are available on only a limited basis for general use. The Aerospace Computer Lab, on the other hand, is available to all students in Aerospace Engineering, and it provides the broadest collection of software and peripherals.

Current Status

The Aerospace Computer Lab is supported by the computing support staff in the AE School. The laboratory is currently open from 8 AM until 4:30 PM. on Monday-Friday. It is operated in an unattended mode during these times. All faculty have direct access to the Lab and can use it for instructional purposes at any time during the week. Supervising graduate teaching assistants for the senior capstone design courses also have access to the Lab and can use it on weekends and evenings for supervised lab sessions. Otherwise, unattended operation of the lab outside normal business hours is not allowed.

Operation of the Aerospace Computer Lab was initiated in the mid-80's with a dozen PC/AT class personal computers. It was upgraded in 1990 with 32 Macintosh IIci systems, an AppleShare file server, an optical scanner, and three laser printers. The Lab was upgraded in Spring 1997 with the addition of 4 high-end Macintosh systems, 4 high-end Windows NT systems and 2 mid-range Windows 95 systems. In 1999, all of the Macintosh systems were finally phased out and replaced with Windows NT systems. In 2001, the older Windows NT systems were upgraded so that all 30 systems currently in the Lab are running either Windows 2k or Windows XP.

Major changes were also made in the network design of the Lab. Previously, the machines in the Lab were members of the AE primary domain, but a single logon was used by all users. It was recognized that such a configuration is very poor from a security point of view, but the support staff simply did not have the resources to administer individual accounts for all AE undergraduates. In addition we found there to be much misuse of the facilities with students setting up various personal servers and trying to assemble collections of hacker tools. In response to this the upgrade in 2001 (funded with Technology Fee funds) included placing the entire Lab behind a firewall system to isolate it from the rest of the AE subnets and the installation of a separate large Windows 2k Server to handle student accounts in the Lab. During Spring 2002 work is being completed on the new network design for the Lab. Each student in an AE class will automatically have an individual account created for that term. This account will either be carried over to the following term if the student continues to enroll in AE classes or it will be archived and deleted within a nominal time following the end of the term. The accounts will have generous storage limits and will allow the students to work on projects and homework without having to keep data on removable storage media. The Lab server will also become the primary instructional web server and will be able to host all the AE class web pages.

The firewall around the Lab effectively separates users in the Lab from the rest of the AE subnets and should prevent much of the misuse previously observed. The firewall design is such that most outgoing transmissions are allowed but almost no ports are open for incoming traffic. As a result, the Lab is all but invisible to the rest of the network. For example, while users may still be able to install an MP3 server on a system in the Lab, it will not be accessible from outside because of the firewall. At the same time, most normal client requests initiated from within the Lab such as web, SSH and license requests will continue to be handled normally.

The Lab supports a suite of software that is appropriate to the educational and research objectives of the School. The core includes word processors, spreadsheets, equation solvers, math systems, graphics systems, network access software, and all software in the suite of software that students are required to purchase. In addition, a smaller number of special purpose software systems are maintained.

The lab hosts specialized software for supporting classes in computational structural analysis, computational aerodynamics, simulation, geometric modeling, and multimedia creation and presentation. In 2001, a major computing resource was added using $65,000 in competitive funding won by Profs. Marilyn Smith and N.M. Komerath from the Technology Fee allotment program. A Beowulf Cluster system was acquired and installed in laboratory space in the Weber Space Science and Technology Building. The grant also allowed acquisition of an initial suite of computational fluid dynamics and flow visualization software. The aim of this facility is to enable professional-level computation programs in fluid mechanics, solid mechanics and aeroelasticity into undergraduate courses. The results from well-validated codes will be made available to formulate realistic problems, assess results using physical insight, and to give students a feel for the usage of such codes within an environment of academic guidance.

The Beowulf cluster is composed of 20 internal nodes (compute nodes with 2 processors on each node) and one external node (server node). Since Beowulf clusters are based on the Linux operating system, each node is based on the 7.2 Red Hat version. The server node provides the interface functionality between the external network and the compute nodes. It also provides the networking services necessary to support the internal network. The internal nodes obtain their needed files systems via NFS and provide authentication and configuration information via NIS through the server node. The server node also performs IP forwarding and acts as a firewall for all internal nodes so that only the external node will be visible from the external network in order to strengthen the security measures of the cluster. In order to facilitate the expected demands of the network traffic produced from servicing the internal nodes, the server node has a 1 Gbit network card for the internal network as well as a 100 Mbit network card for the external network interface. Students have the capability to run Fieldview visualization and Gridgen grid generation software for educational use on the Beowulf cluster. For ease of maintenance, the Beowulf cluster is physically co-located with research computer systems in the Computational Aeroelasticity laboratory in the Space Sciences Building, but it can be accessed from all over the school.

The Undergraduate Computational Laboratory is located in Knight 318 and occupies approximately 700 sq. ft. of space. The room is equipped with an SVGA video projector and be used for classroom instruction where each student has immediate access to a computer. In addition the Lab can be used to host problem-solving sessions for other courses or it can serve as a place for student design teams to work together on a project.

Goals and Objectives for Next 5 Years

Undergraduate computing continues to undergo rapid changes as we move farther into the era of student computer ownership (which started in 1997-98). Initial expectations somewhat naively assumed that student computer ownership would drastically reduce demand on public clusters. Instead, the pronounced increase in student awareness of computing and their growing level of capability has dramatically increased demands on lab facilities that were once targeted for cutback or elimination. AE students have made it clear by their feedback and their presence that the Aerospace Computer Lab continues to be a very important part of the educational process. It lets them work on homework and projects during the day between classes, it provides a place to learn how to use new software under faculty supervision (e.g., simulation codes, structural analysis tools, CFD codes), and it is a place to work on group projects together (adding an important social component to the student learning process). As noted earlier, we have used the Lab to teach the COE 1361 Computing for Engineers course and we have also used it for special lab sections of many other AE courses

As noted in our previous ABET Five Year Plan in 1997, we anticipated significant changes in the Aerospace Computer Lab, and most of our projections proved accurate. We noted that student computers would replace most of the need for utility computing involving tasks such as web browsing, email and document preparation, and this has been true. We also anticipated that the Lab would need to focus on high-end computing needs not easily met by student computers and this was partially correct. Hardware costs have dropped so quickly that single processor performance is no longer an issue. Rather, the Lab provides access to shared multiprocessor computational systems such as the new Beowulf cluster and it provides access to commercial level engineering software that is not practical to license on student computers. Future needs will continue to move more towards higher end computational problem-solving, using high performance multi-processor computers to solve problems such as those involving FEM and CFD or controls simulations. Visualization and CAD software will increasingly demand use of 20 inch or larger monitors.

As a result of these considerations, the new 5-year plan for the Aerospace Computer Laboratory is going to only incrementally different that it was for the past period. The basic long-term goal will continue to be to provide computing systems that are appropriate to the educational program in Aerospace Engineering. The rapid advances in computing technology make this a continual problem, but it is expected that the replaced systems will continue to find productive use.

The short-term goals are the following:

1. *About 1/3 of the systems in the Lab were replaced this year with new Pentium P4 systems but the remaining 2/3rd of computers are 3 year old Pentium P2 systems that are showing their age and will need to be replaced over the next two years.*
2. *The new Beowulf cluster recently made available for student high performance computing is expected to be rapidly consumed as more use is made of computational analysis in the courses and projects. This is also a rapidly developing area of technology and it is expected that even more cost-effective computing, including grid computing will become available and must be incorporated into the Aerospace Computing Lab.*
3. *To date, the majority of the software used in the Lab is provided under very favorable licensing terms, either directly from the manufacturer or through University licensing agreements. We currently provide the MS Office suite, the MS Visual Studio suite, and the Matlab suite under these agreements. However, it is expected that growing requests will be made for other advanced engineering software. Some is currently available (e.g., CATIA and Autocad) but cannot presently be operated from within the firewall structure. Efforts are under way to remedy this situation but we expect increasing requests for new software.*
4. *Continue to carry out student, staff and faculty training on the use of software and hardware in the laboratory. The laboratory setting is very important for this purpose.*

Plan for Reaching Goals and Objectives

A plan for achieving the goal and objectives described previously is in place. From a funding viewpoint, the plan involves a deliberate effort to secure a balance between internal funding and timely grants and donations from external sponsors.

Classroom Facilities

Classroom instruction in Aerospace Engineering is continually being revised, updated and improved to reflect the latest developments in the field and to incorporate the best and most appropriate instructional technology. To support these efforts, all of the classrooms in the AE School are also being continuously improved with the addition of new but proven A/V technology appropriate to our program of undergraduate instruction.

Current Status

The renovation of the Guggenheim Building was completed in 1995, and it provided a renovation of three of the four primary classrooms used for instruction in Aerospace Engineering. Of these, the Design Lab in Room 442 received the most attention, because it was conceived as the centerpiece of our capstone design courses and the primary forum for seminars and other School-wide meetings. The other 2 classrooms in the Guggenheim Building (Rooms 244 and 246) now provide improved instructional settings for typical undergraduate classes. A fourth classroom is in the A. French Building.

Design Lab

The Design Lab (Room 442) is located in the Guggenheim Building in the complex of lab, library and office space that supports the undergraduate design courses and that houses some of the main research computing facilities for the School. The Design Lab is a large tiered classroom seating 100 students. The room is equipped with a double-wide triple-track whiteboard, a cabinet style lectern and a multilevel lighting system (controlled from the lectern). The room design includes provision for future computer networking to each seat and it includes a grid of power outlets above the ceiling for A/V equipment and a future wireless communications system.

The Design Lab was outfitted in 1996 with a state-of-the-art A/V system for enhanced classroom instruction. The system is based on a dual screen projection system with ceiling mounted projectors illuminating two 12 ft. wide drop-down screens mounted above the whiteboards. The system is capable of independently presenting images on both systems from a Windows NT system in the lectern, from a VHS VCR, from a Video Presenter (visualizer), from an auxiliary (laptop) PC or Mac, from the campus video cable network, and from an auxiliary video source. Audio from any of these sources can be played through an audio system. All of the equipment is housed in the lectern which also includes a built-in monitor that can also display any of the various sources. The A/V system is controlled from a small LCD touchpad control unit that can be moved about on the top of the lectern at the convenience of the speaker

The PC system located in the lectern can be readily employed to drive either or both projection systems, with the instructor being able to view selected computer or video signals on the lectern monitor. The computers can be used in a variety of ways ranging from simple still image presentations ("slide shows"), or operational demonstrations, to "live" simulations or more sophisticated multimedia presentations. Since the computers are fully networked, any source from within the Georgia Tech campus or the worldwide Internet can be employed. Faculty can routinely prepare classroom materials on their office or home systems and upload them to the Design Lab computers for presentation at the next class meeting. Or the instructor can, from the lectern, log on to his/her office or lab computer and download instructional or demonstration software, etc. on-line during the class.

The facility was upgraded in 1999 with new higher output and higher resolution LCD projectors using funds competitively acquired under the Technology Fee program. The current projectors provide native XGA resolution at 2100 lumens. This superb A/V facility was designed by a local commercial firm in collaboration with faculty from the School. It was one of the first such installations on the campus and has been in service since September, 1996. It has been used extensively to support upper division and graduate instruction throughout the past academic year and has been used to great advantage for research seminars, industry speakers and special lectures. All faculty who have used the room have expressed enthusiastic support for the facility.

Guggenheim Classrooms 244 and 246

These two classrooms serve as general purpose classrooms seating 50 persons each. As with the Design Lab, these classrooms were configured in the renovation process to be able to support a variety of future technologies including network cabling to each seat as well as ceiling mounted A/V and wireless communications equipment. Multilevel room lighting is controlled from the lectern and a full-width whiteboard, a single pull-down screen and an overhead projector are provided for routine classroom lectures and A/V presentations.

Both of these classrooms were equipped in 1997 with single projector A/V systems that provide equivalent capabilities to those in the Design Lab, as described above. The systems have never proven as useful as that in the Design Lab because they are less versatile (no built-in computer), the lighting levels are not ideal for video projection, and the screen when in use completely obscures the markerboard. In addition, several instances of vandalism have left us with only one fully functional system in Room 244.

Funding has been tentatively allocated from the Technology Fee fund to upgrade one of these rooms to the campus standard for a video-based classroom. The Educational Technologies group in the Office of Information Technology has designed a standard classroom system that is much like what we now have, and they will design and install the upgrade to the facilities in Room 246. We will continue to use the old facility in Room 244 until such time as we are successful in securing additional Technology Fee funds for its upgrade.

A. French Classroom 101

Classroom 101 in the A. French Building seats 40 students and is used for many AE classes. However, the Classroom 101 facilities are over 15 years old and are showing their age along with more obvious wear and tear. The classroom was upgraded with the installation by the Education Technologies group in the Office of Information Technologies on a standard classroom A/V system. This system provides essentially the same functionality as that provided in Classrooms 244 and 246 above. The Engineering Computing Support Department in the College of Engineering is housed in this building and can, on request, provide assistance in the use of these facilities.

Goals and Objectives for Next 5 Years

Classroom instruction will continue to undergo rapid evolution in the coming years as computing and multimedia technologies make their presence felt much more strongly. We are fortunate to have first class physical classroom facilities and to have been able to completely upgrade all but one of these with improved A/V systems. The goals and objectives for the next 5 years will be to sustain this commitment to providing well-proven state-of-the-art instructional equipment in the classrooms.

The five-year goals are to:

1. *Upgrade the computers and computer software in each room, as necessary, to be able to handle the latest multimedia materials, on-line simulations, etc.*
2. *Add DVD capabilities if and when this technology surpasses VCR's and conventional CD's.*
3. *Install local wireless network connections to support student laptop computers if and when they become widely used and/or required.*
4. *Stimulate the exchange among the faculty of their developing experience and knowledge in the use of software and computing systems in the classroom.*

Plan for Reaching Goals and Objectives

A plan for achieving the goal and objectives described previously is in place. As with the Computing Applications Laboratory equipment plan, achieving funding for this plan involves a deliberate effort to balance internal funding and timely grants from outside the department.

SUMMARY

The five-year laboratory plan which has been developed is ambitious. However, it is reasonable when measured against the progress which has been made in the laboratories the last five years. During that period the laboratories have advanced from demonstration-type activities involving often obsolete equipment to hands-on laboratories using the latest instrumentation and methods. .

Perhaps the strongest factor in the success of the laboratory plan is the skill and dedication of the faculty who are involved in the undergraduate laboratories. With proper support, they will shape the undergraduate laboratories so that they are a major component in the success of the long-range plan of the School of Aerospace Engineering to be the top-ranked aerospace school in the country.