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PROGRAM SELF-STUDY REPORT
for

COMPUTER ENGINEERING

Submitted by

The United States Air Force Academy

June 2002

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PROGRAM SELF-STUDY REPORT

for review

of

ENGINEERING PROGRAMS

COMPUTER ENGINEERING

Submitted by

THE UNITED STATES AIR FORCE ACADEMY

JUNE 2002

to the

Engineering Accreditation Commission
Accreditation Board for Engineering and Technology

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PROGRAM SELF-STUDY REPORT

COMPUTER ENGINEERING

Table of Contents

SUBJECT **Page**

A. Background Information 1
1. Degree Titles 1
2. Program Modes 1
3. Actions to Correct Previous Shortcomings 1
4. Contact Information 1

B. Accreditation Summary 3
1. Students 7
1.1 Academic Evaluation, Advising, and Monitoring 7
1.2 Course Transfer and Validation Credit, and Course Substitutions 9

2. Program Operational Goals (POGs) 11
2.1 Background 11
2.2 Development of Program Operational Goals 12
2.3 Program Constituency and Feedback 15
2.4 Sources of Data for Assessing Program Operational Goals Achievement 16
2.5 Analysis and Assessment of Program Operational Goals Data 17
2.6 Graduate Surveys and Program Operational Goals Success Criteria 17
2.7 Proof that the Program Operational Goals Assessment Process is Effective 18
2.8 Ensuring Achievement of the Program Operational Goals Through the Curriculum 20

3. Program Curricular Outcomes (PCOs) and Assessment 21
3.1 Development of Program Curricular Outcomes 22
3.2 Program Curricular Outcomes Relationship to Program Operational Goals and ABET Criterion 3 22
3.3 The Assessment of Program Curricular Outcomes 25
3.3.1 Program Curricular Outcomes Assessment Using Course-Based Objectives 25
3.3.2 Fundamentals of Engineering Exam Support of Program Curricular Outcomes Assessment 29
3.3.3 Comp Engr 465 Skills Review Support of Program Curricular Outcomes Assessment 29
3.3.4 Comp Engr Major's Exit Survey Support of Program Curricular Outcomes Assessment 29

SUBJECT **Page**

3.4 Assessing Program Curricular Outcomes Achievement 30
3.4.1 The Use of Course-Objective Assessments to Evaluate Program Curricular Outcomes Achievement 31
3.4.2 Results from the Fundamentals of Engineering Exam 34
3.4.3 Results from the Computer Engineering Skills Review 34
3.4.4 Results from the Computer Engineering Major's Exit Survey 34
3.4.5 Program Curricular Outcomes Assessment Conclusion 35
3.5 Changes Made to Improve the Program 35
3.6 Lessons Learned During Assessment Process Development and Improvement 37
3.7 Supporting Materials Available for Review by ABET Visitors 38

4. Professional Component 39
4.1 Curriculum 39
4.1.1 Math and Basic Sciences 39
4.1.2 Engineering Topics 40
4.1.3 General Education 40
4.2 Design Experience 40
4.3 Coverage of Engineering Standards and Realistic Constraints 42
4.3.1 Preparation for the Practice of Engineering 42
4.3.2 Honor, Ethics, and Professionalism 43
4.3.3 Process Management 43
4.3.4 Cadet Summer Research Program 44
4.3.5 Student Chapters of the Institute of Electrical and Electronics Engineers (IEEE) and Association of Computing Machinery (ACM) 45
4.3.6 Student Chapter of Tau Beta Pi 45
4.3.7 Fundamentals of Engineering Exam 46

5. Faculty 47
5.1 Adequacy of Faculty 48
5.2 Engineering and Teaching Experience 49
5.3 Professional Development 50
5.4 Participation in Professional Societies 51
5.5 Guidance, Evaluation, and Development of the Program 51

6. Facilities 53
6.1 Adequacy of Facilities 53
6.2 Adequacy of Equipment 56
6.3 Modern Engineering Tools 57
6.4 Lab Safety 58
6.5 Computing and Information Infrastructures 59
6.5.1 Computer Facilities Available for Use in the Engineering Programs 59
6.5.2 Services Available to Assist Cadets and Faculty 61
6.5.3 Accessability of Computer Facilities and Services 61

SUBJECT **Page**

7. Institutional Support and Financial Resources 63
7.1 Adequacy of Institutional Support, Resources, and Constructive Leadership 63
7.1.1 Institutional Support 63
7.1.2 Financial Resources 64
7.1.3 Facilities and Equipment 64
7.1.4 Constructive Leadership 65
7.2 Resources for a Well-qualified Faculty 66
7.2.1 Resources to Attract Faculty 67
7.2.2 Actions to Retain Faculty 67
7.2.3 Actions to Promote Faculty Professional Development 68
7.2.4 Current Area of Concern Related to Program Faculty 69
7.3 Adequacy of Support Personnel and Institutional Services 70
7.3.1 Support Personnel 70
7.3.2 Library 71
7.3.3 Directorate of Education and the Center for Educational Excellence (CEE) 71
7.3.4 10th Communications Squadron 72
7.3.5 Training Devices 72

8. Program Criteria 73
8.1 Program Breadth 74
8.2 Program Depth 75
8.3 Mathematics and Applications 78

9. General Advanced-Level Program 79

Appendices - Additional Program Information
I-A. Tabular Data for Program 81
Table I-1. Basic Level Curriculum 83
Table I-2. Course and Section Size Summary 85
Table I-3. Faculty Workload Summary 86
Table I-4. Faculty Analysis 89
Table I-5. Support Expenditures 96
I-B. Course Syllabi 97
I-C. Faculty Vitae 139
I-D. Summary of Electrical Engineering Laboratory Inventories 215

SUBJECT **PAGE**

Appendix II - Institutional Profile II-1
A. Background Information Relative to the Institution II-1
1. General Information II-1
2. Type of Control II-1
3. Regional or Institutional Accreditation II-1
4. Faculty and Students II-1
5. Mission II-3
6. Institutional Support Units II-4
B. Background Information Relative to the Engineering Unit II-13
1. Engineering Educational Unit II-13
2. Programs Offered and Degrees Granted II-16
3. Information Regarding Administrators II-16
4. Supporting Academic Departments II-16
5. Engineering Finances II-17
6. Engineering Personnel and Policies II-18
7. Engineering Enrollment and Degree Data II-23
8. Definition of Credit Unit II-23
9. Admission and Graduation Requirements, Basic Programs II-24
10. Non-academic Support Units II-26
11. Materials Available for ABET Visitors during Evaluation Visit II-28
12. Summary II-29
C. Tabular Data for Engineering Units II-31
Table II-1. Faculty and Student Count for Institution II-33
Table II-2. Organizational Charts II-34
Table II-3 (Part 1). Engineering Programs Offered II-36
Table II-3 (Part 2). Degrees Awarded and Transcript Designations II-37
Table II-4. Supporting Academic Departments II-38
Table II-5. Support Expenditures II-39
Table II-6. Personnel and Students II-40
Table II-7. Faculty Salary Data II-46
Table II-8. Engineering Enrollment and Degree Data II-47
Table II-9. History of Admissions Standards for Freshmen II-52
D Administrators' Vitae II-53

List of Figures

	FIGURE	PAGE
1	Computer Engineering Assessment Process Overview	15
2	Computer Engineering Assessment Process Flow Chart	26
3	Computer Engineering Course Assessment Process Steps	27

List of Tables

	Table	PAGE
1	Relationship of Program Curricular Outcomes to Program Operational Goals	23
2	Relationship of Program Curricular Outcomes to ABET Criterion 3	24
3	Support of Computer Engineering PCOs by Course Objectives	28
4	Support of the Computer Engineering PCOs by the Computer Engineering Major's Exit Survey	30
5	Cadet Feedback on Clarity of Course Objectives	31
6	Cadet Feedback on the Degree Courses Met Stated Objectives	31
7	AY 00-01: Percentages of Successfully-Achieved Computer Engineering Program Course Objectives Relative to the Program Curricular Outcomes They Support	33
8	Results of the 2001 Computer Engineering Major's Exit Survey, as Related to Program Curricular Outcomes Assessment	34
9	Examples of Assessment-Driven Changes Implemented to Improve the USAFA Computer Engineering Program	36
10	Computer Engineering Classroom and Laboratory Facilities	54
11	Engineering Tools and Expected Cadet Experience Level	58
12	Cadet Computer Purchase History	60
13	Recommended Course Sequence, Class of 2002	77
14	Program Specific Mathematics Topics	79

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Glossary of Terms and Acronyms

Term or Acronym	Description
AIC	Advisor in Charge
APS	Academic Program Summary
AY	Academic Year
CAP	Course Assessment Plan
Classes	Class correspondence according to: First Class = Senior rank, Second Class = Junior rank, Third Class = Sophomore rank, Fourth Class = Freshman rank
Class of xx	Denotes year of graduation, e.g., Class of 2003 graduates in May 2003
Comp Sci	Computer Science
Comp Engr	Computer Engineering
Core	The academic courses in Basic Sciences, Engineering, Humanities, and Social Sciences required of all cadets irrespective of major. Core currently consists of 31 courses: see USAFA Curriculum Handbook
Course Director	Faculty member in charge of a course within the computer engineering program.
CSRP	Cadet Summer Research Program
DFR	Office of the Registrar, Dean of Faculty
Division Chief	Faculty member in charge of a discipline within the computer engineering program.
DF	Dean of Faculty
DFCS	Department of Computer Science (Dean of Faculty, Comp Sci)
DFEE	Department of Electrical Engineering (Dean of Faculty, El Engr)
DoD	Department of Defense
ECEAB	Electrical and Computer Engineering Advisory Board
El Engr	Electrical Engineering
GPA	Grade Point Average
Majors Night	Job-Fair type function allowing undeclared cadets to preview academic disciplines at USAFA
NCA	North Central Association: Provides regional accreditation for the USAF Aacemy as an institution of higher education

Term or Acronym	Description
PCO	Program Curricular Outcome (equivalent to ABET Program Educational Outcome). Statement that defines knowledge, skill, ability at the time of graduation.
PIP	Process Improvement Principal. A member of the Assessment Committee responsible for Electrical and Computer Engineering Program review.
POG	Program Operational Goal (equivalent to ABET Program Objective). Statement that defines observable ability of alumni approximately 2-3 years beyond graduation.
Skills Review	Assessment Instrument: Tests Course Prerequisite Knowledge
TBD	To Be Determined
USAF	United States Air Force
USAFA	United States Air Force Academy

Program Self-Study Report
for
Computer Engineering

A. Background Information

1. Degree Titles

Bachelor of Science in Computer Engineering

2. Program Modes

As with the engineering unit as a whole, the Computer Engineering program is offered in the day mode exclusively. No courses are offered in the evening, co-op, off-campus, or telecommunications modes.

3. Actions to Correct Previous Shortcomings

This will be the first visit of the Engineering Accreditation Committee (EAC) for the Computer Engineering program at USAFA. The program was formed in 1997, with the first graduating class in 2001. As such, there are no identified deficiencies or shortcomings to address.

Note: Even though this is the first EAC accreditation visit for the Computer Engineering program, it did not identify any deficiencies common to all engineering programs at the United States Air Force (USAF) Academy during its last visit in 1996.

4. Contact Information

Please direct questions on the USAF Academy Computer Engineering program to the program's assessment coordinator or either of the program's co-chairs:

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B. Accreditation Summary

The United States Air Force Academy (USAF Academy) has maintained a strong tradition of self-examination and continuous-improvement since it was established in 1954. What was an informal process changed in the early 1990s as the Air Force as a whole adopted a 'total quality' approach to management (TQM), introducing continuous-improvement processes which employed outcomes-based assessment. The creation of Air Force and USAF Academy mission statements that resulted from the adoption of TQM led to the USAF Academy faculty's development of a clearly-defined set of educational outcomes in 1994. Based on these educational outcomes, the faculties of the Departments of Electrical Engineering and Computer Science (which jointly administer the Computer Engineering program) developed mission statements and program goals.

Leveraging these mission statements and program goals, which interfaced well with the EC2000 requirements that were established in the last half of the 1990's, a formal assessment process for the USAF Academy Computer Engineering program was jointly formulated and approved by all faculty members of both the Electrical Engineering and Computer Science departments during 1998-99. Initial, informal feedback from the program's Advisory Board gave the faculty confidence that the process they had developed would improve the product that the program had been established to produce (computer engineers). To provide a similar level of confidence that the program's assessment process could earn ABET accreditation, the program consulted with experienced ABET program evaluators as assessment-process development progressed.

The basis of the Computer Engineering program's assessment process is found in it's Program Operational Goals (POGs), the USAF Academy equivalent of ABET 'Educational Outcomes'. (The term 'Program Operational Goals' reflects the fact that USAF Academy computer engineering majors are all given operational assignments upon graduation.) The POGs define what the program expects of its graduates two-to-three years after graduation. Feedback from the program's constituents is regularly solicited and used as part of the program's continuous-improvement process. To ensure cadets (USAF Academy students) and faculty are fully aware of these goals, they are published on the department's internet and intranet sites, in the USAF Academy Catalog, in "Major's Night" (a form of 'career fair') handouts, and in annually-produced faculty reference binders. They also appear on posters in each classroom and in the main reception areas of the Electrical Engineering and Computer Science offices.

To facilitate the attainment of Program Operational Goals, the faculty developed measurable Program Curricular Outcomes (PCOs), the USAF Academy equivalent of ABET 'Program Outcomes'. These outcomes define the attributes we expect of Computer Engineering majors upon graduation. Building upon a USAF Academy legacy of continuous *course* evaluation and improvement, the faculty chose to focus the PCO assessment process on cadet achievements in individual courses. As a result, each course in the program has a defined goal and measurable objectives; each of these objectives is then 'mapped' to one or more Program Curricular Outcome. Such course-based assessment requires attention to detail at the lowest level; to achieve this, each course has a designated Course Director who is

responsible for administering the course and all supporting instructors, and assessing cadet achievements. To assess issues beyond the scope of individual courses, course-based assessments are supplemented by surveys and examinations taken by some or all of the members of each year's graduating class.

To ensure the faculty, monetary, and physical resources are available to attain Program Operational Goals and Program Curricular Outcomes, the faculty found it necessary to also create Supporting Goals and Objectives. Assessing the achievement of Supporting Objectives serves as a measure of program 'health' beyond what is directly experienced by the cadets. Assessing recruiting, development, and support of faculty and staff ensure the program's human resources are sufficient to implement the academic program. Likewise, planning for and acquiring adequate facilities, supplies, and equipment is essential to support curriculum delivery and faculty/cadet research.

To implement the Computer Engineering assessment process the departments are functionally organized into administrative units, called Divisions, each of which is responsible for the delivery, support, and assessment of a sequence of courses. Division Chiefs are responsible for integrating their course sequence to accomplish Program Curricular Outcomes, thereby supporting Program Operational Goals. Since they control and assess the resources (faculty and facilities) assigned to support their course sequence they also employ the Supporting Goals and Objectives every day. As key figures in executing the day-to-day aspects of the Computer Engineering program, the Division Chiefs also provide a large part of the inputs for the program's assessment process. Division Chiefs also serve as members of the Computer Engineering Curriculum Committee, which approves curricular changes within the program. On-going process improvement is handled by the program's Director of Assessment who chairs a standing committee of senior faculty members known as the Process Improvement Principals (PIPs).

The Electrical Engineering and Computer Science departments have compiled a single document, known as the Program Assessment Plan, to guide faculty members as they implement the continuous-improvement process outlined above. This document includes a task-based Program Assessment Schedule containing the timelines of assessment activities for an entire assessment year, with all reports for the prior assessment year. The schedule also identifies the administrative position within the program responsible for accomplishing each assessment task. As an example of the program's continuous process improvement, the Program Assessment Schedule is also being integrated into the faculty's Outlook Calendar, with implementation planned for the 2002-2003 academic year.

Course Directors and the Division Chiefs report assessment results at the end of each semester. These reports consist of:

- Course Briefings for the upcoming semester
- Course Assessment Reports for the semester just concluded
- Division Mid-Year or Year-End Assessment Briefing
- Division Year-End Assessment Report (Spring Only)

Course and Division report results, along with program-level assessments, are incorporated into the Program Annual Assessment Report before 1 August. Program faculty members are briefed on the results during the Fall semester. Finally, all the data and reports are stored in a Program Assessment Repository according to the Program Assessment Repository Schema (contained in the Program Assessment Plan).

The Computer Engineering program's assessment processes (described above) are implemented by an outstanding faculty and staff dedicated to excellence in undergraduate engineering education. The program is designed to provide a challenging curriculum and supportive environment for every cadet. These well-defined processes ensure the curriculum, facilities, personnel, and support services necessary to meet the Program Operational Goals and the Program Curricular Outcomes are available. Regular internal and external feedback are analyzed and used to continually improve these processes.

For more information about the Computer Engineering program and its assessment processes, please access <http://www.usafa.af.mil/dfee/ > and select 'assessment'.

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1. Students

The quality and performance of the students and graduates are important considerations in the evaluation of an engineering program. The institution must evaluate, advise, and monitor students to determine its success in meeting program objectives. The institution must have and enforce policies for the acceptance of transfer students and for the validation of courses taken for credit elsewhere. The institution must also have and enforce procedures to assure that all students meet all program requirements.

The admissions criteria used by the Academy are set by the Secretary of the Air Force. On entering, cadets must be 17 to 23 years of age, of high moral character, and qualified for service in the U.S. Air Force. The following factors are evaluated: Prior Academic Achievement (high school and college), College Board and Aptitude and Achievement scores or American College Testing Scores, Athletic and Non-athletic Activities Score, Candidate Fitness Test, Medical Examination, and Selection Panel Scores. A weighted Selection Composite Score is computed for each applicant. This score is a summary of factors that best indicate potential for success at the Academy and a high probability of a successful career in the Air Force.

Successful applicants must rank in the top 40 percent of their high school class, must score at least 580 on the SAT verbal aptitude exam and 560 on the math aptitude exam, or must score at least 24 on the ACT English exam and 25 on the math exam. In addition, scores of 24 for the ACT Reading and 25 for the ACT Science Reasoning are also required. For the past six years, the average ACT score was 28.92 and the average SAT score was 1282.

The Superintendent of the U.S. Air Force Academy, Lieutenant General John R. Dallager, testified before a senate defense subcommittee on June 5, 2002, that applications to the academy are on the rise. More than 16,500 men and women applied for the 1200 openings in the class of 2006. The average combined SAT score for those selected was 1,310, and their average high school grade-point average was better than 3.9 on a 4.0 scale. "The qualifications of applicants are at an all-time high resulting in an extraordinarily competitive and extremely challenging selection process," Dallager said. "Clearly there is an abundance of patriotic, high-achieving, goal-oriented, young people that are eager to learn and earn commissions in order to serve their country," he said.

As of 1 May 2002, 51 cadets (freshman through seniors) were enrolled in the Computer Engineering major. At late May's graduation for the Class of 2002, 16 cadets were awarded Computer Engineering degrees. The remaining majors are distributed as follows: 5 in the Class of 2003, 16 in the Class of 2004, and 14 in the Class of 2005.

1.1 Academic Evaluation, Advising, and Monitoring

A thoroughly-integrated, three-level system for evaluation, advising, and monitoring is used to ensure Computer Engineering majors meet all graduation requirements.

This system involves the cadet, faculty advisor, program Advisor-in-Charge (AIC), and Class Coordinators from the Office of the Registrar.

When a cadet decides to declare the Computer Engineering major, they first meet with the program's Advisor-in-Charge. The Advisor-in-Charge evaluates the cadet's ability to succeed in Computer Engineering by reviewing the student's current Academic Program Summary (APS), which lists courses completed and grades earned to that point in time. If the cadet decides to proceed with the declaration, the AIC accesses the Office of the Registrar's student database program (known as Q2i) and officially declares the cadet a Computer Engineering major. The AIC also assigns the cadet to a faculty advisor after generating an initial schedule of courses that will result in the cadet meeting all requirements for a degree in Computer Engineering.

The cadet and faculty advisor are responsible for monitoring the cadet's academic program schedule, and academic performance. Cadets are expected to meet with their advisors at least once each semester to review course loading, academic progress, and to update their academic schedule (if necessary) using Q2i. Faculty advisors review the cadet's performance at mid-semester and at the end of the semester. If a cadet is deficient, the advisor consults with the cadet's instructors. If the cadet is placed on academic probation, the advisor assists the cadet in developing a formal "get-well" program and monitors the cadet's progress. Faculty members are encouraged to discuss areas of concern with the faculty advisors at any time during the semester. To assist in cadet workload management the faculty provide cadets with an assignment "de-confliction" matrix for El Engr and Comp Sci courses taken during sophomore, junior, and senior years.

When the advisor makes changes to the cadet's program, Q2i automatically notifies the AIC to review and approve the changes. The Advisor-in-Charge reviews the APS to ensure prerequisites and program requirements are satisfied. When the Advisor-in-Charge approves the changes, the APS is forwarded to the Office of the Registrar, again through Q2i, where it is subjected to computer review for compliance with the Academy's graduation requirements for Computer Engineering.

In the Office of the Registrar, Class Coordinators and Records Managers are assigned to each class (year) of cadets. Class coordinators are responsible for monitoring and approving changes to an academic schedule. Records managers check the program (after computer-update) to ensure graduation requirements are met. The First (senior) Class Records Manager ultimately confirms, prior to graduation, that all degree requirements for a graduating senior have been satisfied.

NOTE: Since all possible Computer Engineering electives that satisfy program graduation requirements also satisfy ABET requirements, completion of an ABET-accredited program is ensured. Detailed information on the Computer Engineering curriculum is available to cadets and faculty in the USAF Academy Curriculum Handbook. An example of an Academic Program Summary, and its associated

computer-generated graduation requirements check, are contained in the Curriculum Handbook.

1.2 Course Transfer and Validation Credit, and Course Substitutions

Since the Air Force Academy is a mandatory four-year residence program, very few cadets request transfer credit for major's courses contained in the Computer Engineering program. The policy of the USAF Academy with respect to advanced standing is stated in USAF Academy Regulation 537-21, Transfer and Validation Credit and Fourth Class Registration. Transfer credit is only awarded for corresponding college-level courses taken at a college, university, or secondary school. A grade of "B" or higher must be achieved for award of transfer credit. Transfer credits may be applied toward graduation requirements, but not toward residency requirements.

The Office of the Registrar organizes and supervises the evaluation of courses for transfer credit. A cadet who wishes to receive transfer credit for Electrical Engineering, Computer Science, or Computer Engineering courses must submit a request for evaluation to the Deputy Program Head through the Advisor-in-Charge. Material reviewed for transfer determination includes course description, text used, and chapter coverage. If any questions persist concerning curriculum content after an interview with the cadet, the institution from which the course was taken is contacted.

Occasionally a cadet completes one semester in a USAF Academy-sponsored exchange program. In these instances the cadet's entire program is evaluated by the advisor, the Advisor-in-Charge, and the Deputy Program Head. Transfer credit is awarded only after verification that the course content is substantially the same. The majority of classes taken during exchange programs are core-course equivalents, rather than major's courses.

A cadet must have at least eight semesters in residence at the USAF Academy. However, a semester spent in a USAF Academy-sponsored exchange program does count as a semester in residence. A cadet must take at least 136 semester hours at the USAF Academy (including those completed in USAF Academy-sponsored exchange programs) to satisfy residency requirements, regardless of semester hours transferred and validated. Courses which do not fulfill residency requirements include those validated or transferred, courses carrying no semester hour credit, pass/fail courses, core preparation courses and courses failed.

Substitutions for courses in the Computer Engineering program are extremely rare. A formal request for waiver must be submitted and approved by the advisor, the Advisor-in-Charge, and one of the Computer Engineering Program Co-Chairs. Each of these individuals must confirm that the substitute course fulfills the program requirements satisfied by the original course. If another department offers the

course, approval from that Department Head is also required. Finally, if the course is a core course, the Vice Dean must approve the request.

2. Program Operational Goals (POGs)

Each engineering program for which an institution seeks accreditation or re-accreditation must have in place:
(a) detailed published educational objectives that are consistent with the mission of the institution and these criteria
(b) a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated
(c) a curriculum and processes that ensure the achievement of these objectives
(d) a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program

Note to the Reader: Program Operational Goals (POGs) are the USAF Academy equivalent of ABET "Educational Outcomes", and define the attributes the program expects of its graduates two-to-three years after graduation. The word "operational" is used to emphasize that these attributes will be measured after the graduates are serving on active duty in an "operational" assignment. Great care was taken to ensure these Program Operational Goals support the Dean of Faculty Educational Outcomes. In addition, the development of the Program Operational Goals ensured there was a way to validate them and evaluate whether or not they are achieved. The details of these measurements and how the results will be assessed is presented later in this section.

Based on evaluations done during the last two assessment cycles, the program's cadets, faculty, and external constituents are familiar with the Program Operational Goals, which are posted in every classroom and laboratory. They were thoughtfully developed, validated externally and internally, and are in integral part of the continuous-improvement process strategy for the Computer Engineering program at the USAF Academy. Their achievement will be formally assessed when the program's graduates have served in operational assignments for at least two years. The first class containing Computer Engineering graduates was the Class of 2001.

2.1 Background

The USAF Academy has maintained a strong tradition of self-examination and continuous-improvement since it was established in 1954. What was an informal process changed in the early 1990s as the Air Force adopted a "total quality" approach to management, introducing continuous-improvement processes which employed outcomes-based assessment. The resultant creation of Air Force and USAF Academy mission statements led to senior USAF Academy faculty administrators developing a clearly-defined set of educational outcomes in 1994. Based on these educational outcomes, the faculties of the Departments of Electrical Engineering and Computer Science (which jointly administer the Computer Engineering program) each developed mission statements and program goals.

In the summer of 1994, an Educational Outcomes Assessment Working Group was formed. Initially comprised of 20 faculty volunteers, the group eventually involved over 50 faculty and students. They assessed the contributions of each of

the 35 required core courses to the achievements of three of the institution's stated educational outcomes. Following this institutional lead, the Departments of Electrical Engineering and Computer Science, as well as the other academic departments, developed unit self-assessment programs. By 1997, the two departments' senior faculty concluded that this initial effort at self-assessment had provided significant benefit, but did not result in a sustainable process. In 1998 the Department of Electrical Engineering (DFEE) performed a systematic review of the unit self-assessment process in order to address deficiencies and expand it to cover both an Electrical Engineering program, and the newly-implemented Computer Engineering program. The faculty undertook this task with three goals in mind:

1. Expand the mission statement beyond the scope of supporting the Dean of Faculty Educational Outcomes.
2. Generate complete, focused goals for the programs.
3. Ensure that all objectives generated to support program goals were measurable.

Leveraging these mission statements and program goals, which interfaced well with the EC2000 requirements that were established in the last half of the 1990's, a formal assessment process for the USAF Academy Computer Engineering program was jointly formulated and approved by all faculty members of both the Electrical Engineering and Computer Science departments during 1998-99. Initial, informal feedback from the program's Advisory Board gave the faculty confidence that the process they had developed would improve the product that the program had been established to produce (computer engineers). To provide a similar level of confidence that the program's assessment process could earn ABET accreditation, the program consulted with experienced ABET program evaluators as assessment-process development progressed.

2.2 Development of Program Operational Goals (POGs)

The Computer Engineering program exists to support the mission of the USAF. From the USAF mission flows the missions of the Air Force Academy, the Dean of the Faculty, and the departments/programs. This hierarchy of missions is listed below.

The USAF mission is:

To defend the United States through control and exploitation of air and space

The USAF Academy mission is to:

Inspire and develop outstanding young men and women to become Air Force officers with knowledge, character, and discipline; motivated to lead the world's greatest aerospace force in service to the nation.

The Dean of Faculty's mission is to:

Inspire and educate cadets and faculty to serve our nation with integrity in peace and war.

The Department of Electrical Engineering's mission is:

To produce graduates motivated and able to excel as officers in a technologically sophisticated Air Force.

The Department of Computer Science's mission statement is as follows:

To produce officers able to apply computing principles and technologies effectively in the defense of our nation.

Using the hierarchy of mission statements above, and following the structure suggested by ABET, the Department of Electrical Engineering and Department of Computer Science faculty drafted Program Operational Goals that describe the desired performance of our graduates two to three years after graduation. These goals are listed below:

Computer Engineering Program Operational Goals

Two to three years after graduation the Department of Electrical Engineering and the Department of Computer Science expect their graduates to be officers who:

1) *Possess breadth of integrated, fundamental knowledge in the basic sciences, engineering, humanities, and social sciences; and depth of knowledge in Computer Engineering.*
2) *Can communicate effectively.*
3) *Can work effectively with others.*
4) *Are independent thinkers and learners.*
5) *Can apply their knowledge and skills to solve Air Force engineering problems, both well and ill defined.*
6) *Know and practice their ethical and professional responsibilities as embodied in the United States Air Force core values.*

The faculty realized that ABET's intent is for a program's constituents (the students, the potential employers of the graduate, the graduates, and the faculty) to establish the Program Operational Goals. However, at the USAF Academy many faculty members are graduates, and the faculty can also be considered potential employers. This situation occurs because the Air Force assigns qualified active duty officers as faculty members for relatively short terms (three to four years). These officers come from, then return to, USAF organizations that often have USAF Academy graduates assigned. Thus, on assignments prior or subsequent to teaching, it is likely that faculty members will have graduates working for them. It was for these reasons that the faculty was comfortable drafting the initial version of the Program Operational Goals, which were subsequently validated by the program's advisory board.

The complete assessment process for the Computer Engineering program can be found in Figure 1. In addition to highlighting the relationship of the mission statements (described above) to the Program Operational Goals, it also illustrates how the program's constituents provide feedback for continuous improvement. In this process the Program Operational Goals reside at the top, along with the Program Curricular Outcomes. Program Curricular Outcomes define the desired attributes of our graduates at the end of their undergraduate academic experience. The assessment/feedback/change process can be seen in the diagram. The details of Program Operational Goals data collection and analysis are described below, along with a definition of the program's constituency.

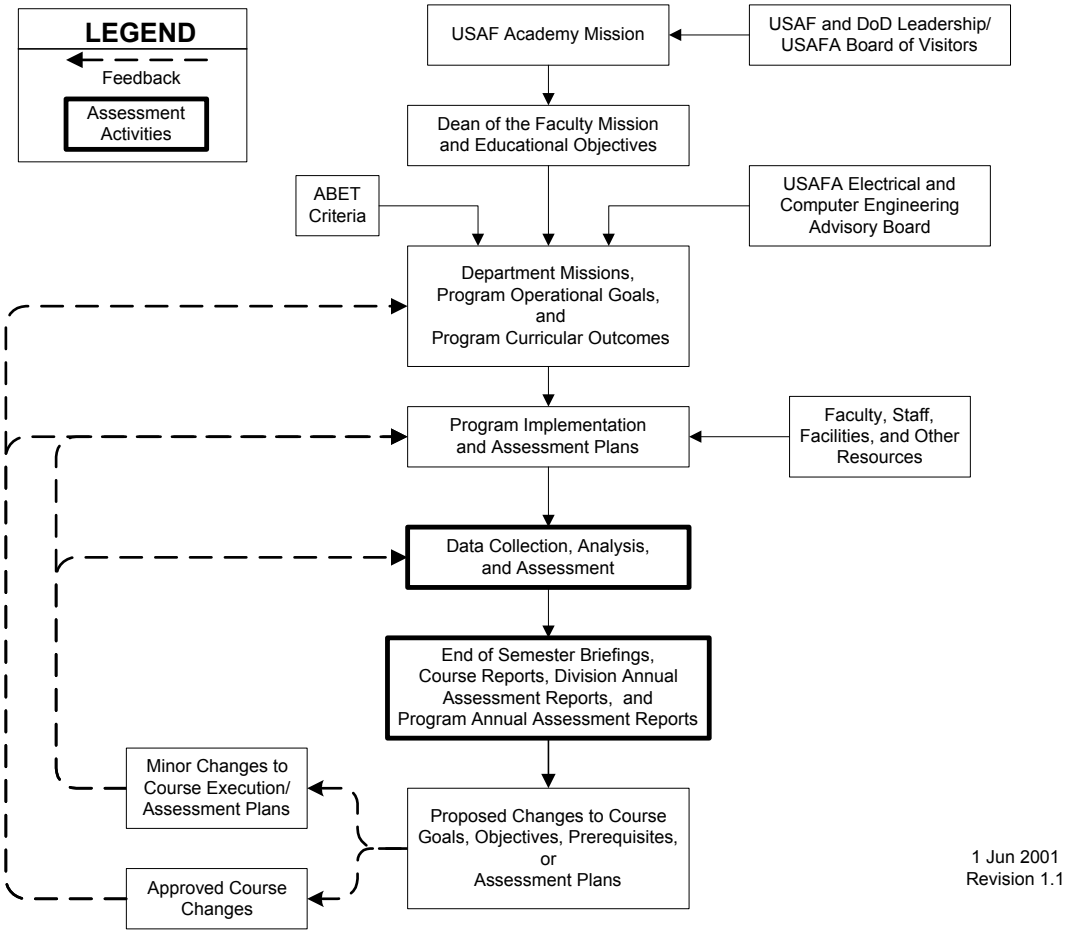

Figure 1. Computer Engineering Assessment Process Overview

2.3 Program Constituency and Feedback

There has always been informal feedback from the USAF constituency regarding performance of USAF Academy graduates. This process was formalized by establishing a USAF Academy Electrical and Computer Engineering Advisory Board that meets at the USAF Academy every year. In addition, supervisor and graduate surveys have been created to validate the Program Operational Goals by evaluating the job performance of our graduates a few years after graduation. New faculty members are surveyed as they arrive in the Department of Electrical Engineering or Department of Computer Science from operational USAF assignments. Finally, the success of program graduates is also assessed if they attend graduate school.

The USAF Academy Electrical and Computer Engineering Advisory Board is comprised of eight to ten individuals who are first- or second-line supervisors of graduates who have been assigned to engineering jobs within the USAF. Advisory

Board membership is determined by examining USAF assignment records and/or USAF Academy Association of Graduates records to determine which USAF organizations have the largest concentrations of program graduates. Care is taken to ensure adequate representation of both electrical and computer engineers. The membership of the Advisory Board is reviewed every three years to ensure that it remains representative of the distribution of graduates.

The Advisory Board meets with both the Electrical Engineering and Computer Engineering programs' leadership once a year at the USAF Academy. The agenda is designed to solicit maximum quantitative data, as well as subjective opinions from Board members regarding their experience with our graduates. In addition, the Program Operational Goals, program assessment processes, and results from the previous assessment cycle are reviewed with the Board.

2.4 Sources of Data for Assessing Program Operational Goals Achievement

Successful achievement of the Program Operational Goals is determined by analyzing data obtained from both internal and external sources. Internally, the program measures cadet performance relative to stated objectives in individual courses. Externally, Program Operational Goals achievement will be assessed mainly through constituent surveys (graduates, USAF supervisors, faculty, and staff), once our graduates have had sufficient time in operational assignments. In addition, qualitative feedback about the Program Operational Goals is obtained from the Advisory Board.

Internal support for achieving Program Operational Goals (listed in Section 2.2) can be seen by examining the Computer Engineering major's curriculum. Regarding breadth, the rich core requirements spanning humanities, social sciences, basic sciences, and engineering courses must be completed by all cadets. The depth of knowledge in Computer Engineering is supported by the requirement that cadets take multiple courses in signals and systems, digital system design, electronic systems, and computer science. Communication skills are supported by the various presentations and papers required in a broad number of courses. The many team-oriented activities required at a military service academy support the goal of working effectively with others, and numerous course assignments support the goal of developing independent thinkers and learners. All the engineering and algorithm design courses support the goal of developing the ability to solve Air Force engineering problems. Ethical and professional responsibilities are explored in a variety of courses, including many engineering courses, a required philosophy course (that focuses on ethics), and a required law course.

Collection of data from external sources will begin in 2004, when the Computer Engineering program will administer a survey at the beginning of each calendar year to graduates and their supervisors. The same survey will also be administered to new military faculty soon after they arrive in the Department of Electrical Engineering or Department of Computer Science to take advantage of their recent

USAF experience. These surveys will query the respondents to indicate how well they feel the program meets its Program Operational Goals, solicit written comments, and ask respondents to suggest changes if they think the Program Operational Goals are not a complete and correct set of operational goals. Responses to the surveys will be stored directly into a database.

Another external source of data, graduate school records for recent graduates, will also be collected and analyzed as a measure of how well graduates were prepared for an educational experience at another institution.

2.5 Analysis and Assessment of Program Operational Goals Data

The assessment of internally-collected data relative to course-objective attainment is described in detail in Section 3 of this report. Externally-collected graduate school records, survey data, and feedback from the Advisory Board will be reduced and analyzed to determine:

- if graduates who achieved at least a 3.0/4.0 grade-point average at USAFA were successful in graduate school,
- the degree to which graduates feel their education and the curriculum prepared them for their job challenges,
- the degree to which supervisors think graduates are performing to the levels described in the Program Operational Goals,
- the degree to which the Advisory Board agrees the curriculum adequately prepares graduates to perform to Program Operational Goals standards after they graduate,
- if the survey responses indicate changes to the curriculum or Department operations are desirable,
- if Advisory Board questions and comments suggest changes to the curriculum or Department operations, and
- if the survey questions and the Advisory Board meeting agenda were effective in soliciting an accurate response that measures the Program Operational Goals.

The raw and reduced data collected/generated will be stored in the Program Assessment Repository. The Program Assessment Repository resides on a network server to ensure backups are routinely accomplished. If any assessment files are maintained on desktop computers, those files will be uploaded to a server at least weekly.

2.6 Graduate Surveys and Program Operational Goals Success Criteria

Once our graduates have enough operational experience (two-to-three years), assessment surveys will be administered. On the assessment surveys, a six-point scale will be used to determine if the program is successfully meeting its Program Operational Goals. Responses to the surveys of four, five, or six (Slightly Agree, Agree, and Strongly Agree, respectively) for a positive question and one, two, or three for a negative question (Strongly Disagree, Disagree, and Slightly Disagree,

respectively) will be considered satisfactory. When evaluating graduates pursuing advanced education, a graduate school success rate near 100 percent is expected for those who achieved at least a 3.0/4.0 grade-point average at the USAF Academy.

2.7 Proof That the Program Operational Goals Assessment Process is Effective

Given the fact that the program graduated its first Computer Engineers in 2001, no quantitative data exists to prove the program is achieving its Operational Goals. However, the program can offer proof that the USAF constituent is actively involved in defining the process that will lead to the success the program expects. The following information is taken (unedited) from the document *"Minutes of Electrical and Computer Engineering (ECE) Advisory Board Meeting – 10 November 2000"*. (When the phrase 'survey result' is used, it refers to surveys completed by the institution's Electrical Engineering graduates and supervisors.)

2. Discussion: Col Neal welcomed the advisory board members and explained the reason for the meeting which was to obtain approval from the advisory board of the Program Operational Goals (POGs) for the Electrical Engineering and Computer Engineering degree programs and discuss the results of the surveys the board members returned.
   a. Lt Col Wright reviewed the previous Accreditation Board for Engineering and Technology (ABET) criteria and introduced the new EC2000 accreditation criteria that focus on continuous improvement with assessment processes. Gen Royer explained that accreditation is desired by the Air Force because of the Air Force Specialty Code requirements. Col Neal explained that by meeting the minimum standards set by ABET for all US engineering programs, our programs are competitive with any other accredited school which helps USAF Academy recruitment. The Dean strongly supports accreditation. Accreditation helps for professional licensing and also serves as a third party check on the quality of our programs. The Electrical Engineering and the Computer Engineering Program Operational Goals were presented to the board.
   b. Gen Royer briefed the survey results. The board had comments on some wording and all responses with less than a 4.0 (out of 5.0) average were reviewed.
      1) "*Officers who are independent learners*." This POG addresses the motivation and toolset for cadets to continue their learning after graduation. Since they need to "think" critically as well as "learn," the advisory board recommended we change to read "independent thinkers and learners." DFEE and DFCS agreed to consider this change.
      2) "*Officers who know their ethical and professional responsibilities as embodied in the United States Air Force core values of 'Integrity First, Service before Self, and Excellence in all we do.'*" This POG addresses the graduate's knowledge of ethical and professional responsibilities. Board members would prefer a more active goal, e.g., "know and

practice." DFEE and DFCS agreed to consider modifying with words such as "exhibit" or "practice."

3) "*Academy-educated electrical engineering graduates have a sufficient grounding in radio frequency circuit theory, devices, systems and propagation.*" Reviewed because of one very low score. All agreed that the wording indicates a "sufficient" level of understanding, which depends on the job. Therefore, this question should be answered in the context of the organization. Survey instructions will be modified to reflect this.
4) "*Academy-educated electrical engineering graduates keep current with Air Force issues."* All agreed that graduates should keep current with Air Force issues, but the board expressed concerns about the departments' impact in this area. DFEE explained that while we depend heavily on the core program to meet this need, all courses try to use Air Force issues as examples at least once a month. The upper level classes use Air Force articles/issues in class at least once a month. No change will be made to this question.
5) "*Academy-educated electrical engineering graduates accept the challenges of Air Force engineering without complaining about perceived differences in the practice of engineering in the civilian sector."* The consensus was that graduates have unrealistic expectations for their jobs. The Academy can better inform them about the types of jobs available upon graduation. The ECE advisory board agreed to help with displays for majors night and guest speakers for our majors courses and professional society student chapter meetings.

3. Action Items (Responsible Individual, Expected Completion Date):
   c. POG modification – DFEE and DFCS will consider rewording the two POGs as indicated in paragraphs 2.b.1 and 2.b.2 and report results to the ECE Advisory Board (Gen Royer, 8 Dec 00)

As reported in the 2 February 2001 document *"MEMORANDUM FOR ELECTRICAL and COMPUTER ENGINEERING ADVISORY BOARD"* with the Subject line *"Status of Action Items from Electrical and Computer Engineering (ECE) Advisory Board Meeting held 10 November 2000"*, this action item was cleared. Below is the unedited material from that document.

1. The following list is the Action Items from our Fall 2000 meeting and their status. Where appropriate and when so noted, the results of the Actions Items are included as attachments.
   c. POG modification – DFEE and DFCS will consider rewording the two POGs as indicated in paragraphs 2.b.1 and 2.b.2 (of the minutes) and report results to the ECE Advisory Board (Gen Royer, 8 Dec 00)
   STATUS: Suggested changes were considered and adopted. Reworded Program Operational Goals are attached. Action Item completed.

2.8 Ensuring Achievement of the Program Operational Goals Through the Curriculum

The Program Operational Goals listed in Section 2.2 are fully supported by the electrical engineering major curriculum. Regarding breadth, the rich core requirements spanning humanities, social sciences, basic sciences, and engineering courses must be completed by all cadets. The depth of knowledge in Computer Engineering is supported by multiple major's courses in each of the following areas: signals and systems; digital systems; electronic systems; computer science; and a culminating design experience. Communication skills are supported by the various presentations and papers required in a large number of courses. The many team-oriented activities required at a military service academy support the goal of working effectively with others, and the numerous course assignments support the goal of developing independent thinkers and learners. All the engineering courses support the goal of developing the ability to solve Air Force engineering problems. Ethical and professional responsibilities are explored in a variety of courses, including many engineering courses, a required philosophy course, and a required law course.

The Program Operational Goals have been thoughtfully developed, validated externally and internally, and are an integral part of the overall continuous process improvement strategy of the Electrical Engineering program at the U.S. Air Force Academy.

3. Program Curricular Outcomes (PCOs) and Assessment

Engineering programs must demonstrate that their graduates have:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program, including those listed above, are being measured. Evidence that may be used includes, but is not limited to the following: student portfolios, including design projects; nationally-normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates.

Program Curricular Outcomes (PCOs) are the attributes that the Computer Engineering program expects of its majors upon graduation. The word "curricular" emphasizes the source of knowledge for the expected behavior, while "outcomes" follows from common academic usage and the ABET terminology in Criterion 3. Thus, the US Air Force Academy's Program Curricular Outcomes are the equivalent of ABET's "Program Outcomes."

Great care was taken during the creation of Computer Engineering's Program Curricular Outcomes to ensure they were assessable, and would support the Program Operational Goals described in the previous section (thereby supporting Dean of Faculty, USAF Academy, and Air Force missions). They were also crafted to incorporate the outcomes defined in ABET Criterion 3. As a result, if measured cadet performance (with respect to Program Curricular Outcomes) is assessed as successful the program can be confident it is meeting institutional needs, as well as ABET accreditation requirements. The course-based assessment process that was developed in conjunction with the Program Curricular Outcomes ensures a systematic focus on data collection, reduction, and analysis. It enables the faculty to assess and direct the effectiveness of the program toward meeting these stated outcomes and goals.

In this section the Program Curricular Outcomes are listed and related to the Program Operational Goals, and to the outcome requirements of ABET Criterion 3. The assessment process for Program Curricular Outcomes, based on the attainment of course objectives, is explained in detail. The data used to assess the Program Curricular Outcomes is presented and analyzed, and the use of these results to improve the Computer Engineering program is demonstrated. Finally, the materials that will be

available during the visit to demonstrate achievement of the Program Operational Goals and Program Curricular Outcomes is described.

3.1 Development of Program Curricular Outcomes (PCOs)

Building upon a USAF Academy legacy of continuous *course* evaluation and improvement, the faculty chose to focus the Computer Engineering program's assessment process on cadet achievements in individual courses. Starting with the Program Operational Goals and individual course objectives, the faculty drafted a set of measurable Program Curricular Outcomes. Through a succession of faculty meetings, the outcomes were combined, refined, voted upon, and accepted. These Program Curricular Outcomes are listed below.

Computer Engineering Program Curricular Outcomes

Each Computer Engineering graduate shall demonstrate satisfactory:

1) *Application of the fundamental concepts of computer engineering to solve engineering problems.*
2) *Laboratory techniques including procedures, recording, and analysis.*
3) *Design, fabrication, and test techniques.*
4) *Use of contemporary computer engineering analysis, design, and test tools.*
5) *Written and oral communication skills.*
6) *Knowledge of ethical and professional responsibilities.*
7) *Breadth and depth of knowledge and skills in computer engineering, computer science, electrical engineering, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.*
8) *Knowledge of the benefits and the skills needed to engage in life-long learning.*
9) *Ability to be effective multidisciplinary team members.*
10) *Skills to be an independent learner while knowing when to seek help.*
11) *Knowledge of the role of Air Force engineering officers in our global society.*
12) *Knowledge of contemporary social, political, military, and engineering issues.*

3.2 Program Curricular Outcomes Relationship to Program Operational Goals and ABET Criterion 3

Program Curricular Outcomes were developed to ensure that program graduates can achieve the stated Program Operational Goals within two-to-three years after completing their undergraduate education. The relationship of Program Curricular Outcomes to Program Operational Goals is shown in Table 1.

The relationships shown in Table 1 undergo an annual review by the department's standing process improvement committee (consisting of the Process Improvement Principals (PIPs)) for accuracy and completeness. Although Program Curricular Outcome assessment does not in-and-of itself provide direct feedback that the Program Operational Goals are being met, it does serve as an indicator of whether or not graduates can satisfy those goals in an operational assignment.

Table 1. Relationship of Program Curricular Outcomes to Program Operational Goals

Program Curricular Outcomes \ Program Operational Goals		1	2	3	4	5	6
		Possess breadth of integrated, fundamental knowledge in the basic sciences, engineering, humanities, and social sciences; and depth of knowledge in Computer Engineering	Communicate effectively	Work effectively with others	Be independent thinkers and learners	Apply their knowledge and skills to solve Air Force engineering problems, both well and ill defined	Know and practice their ethical and professional responsibilities as embodied in the United States Air Force core values
Each Computer Engineering graduate shall demonstrate satisfactory:							
1	Application of the fundamental concepts of computer engineering to solve engineering problems	X				X	
2	Laboratory techniques including procedures, recording, and analysis.	X				X	
3	Design, fabrication, and test techniques.	X				X	
4	Use of contemporary computer engineering analysis, design, and test tools.	X				X	
5	Written and oral communication skills.		X	X			
6	Knowledge of ethical and professional responsibilities.						X
7	Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.	X				X	
8	Knowledge of the benefits and the skills needed to engage in life-long learning.				X		
9	Ability to be effective multidisciplinary team members.		X	X		X	
10	Skills to be an independent learner while knowing when to seek help.				X		
11	Knowledge of the role of Air Force engineering officers in our global society.						X
12	Knowledge of contemporary social, political, military, and engineering issues.	X			X	X	

In addition to supporting the Air Force's Program Operational Goals, the program is also designed to produce competent engineers as defined by items a-k of ABET Criterion 3. Table 2 indicates how each of the Program Curricular Outcomes supports at least one of the ABET Criterion 3 items.

Table 2. Relationship of Program Curricular Outcomes to ABET Criterion 3

	ABET Criterion 3 / **Program Curricular Outcomes**	**a** an ability to apply knowledge of mathematics, science, and engineering	**b** an ability to design and conduct experiments, as well as to analyze and interpret data	**c** an ability to design a system, component, or process to meet desired needs	**d** an ability to function on multi-disciplinary teams	**e** an ability to identify, formulate, and solve engineering problems	**f** an understanding of professional and ethical responsibility	**g** an ability to communicate effectively	**h** the broad education necessary to understand the impact of engineering solutions in a global and societal context	**i** a recognition of the need for, and an ability to engage in life-long learning	**j** a knowledge of contemporary issues	**k** an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
	Each Computer Engineering graduate shall demonstrate satisfactory:											
1	Application of the fundamental concepts of computer engineering to solve engineering problems.					X						
2	Laboratory techniques including procedures, recording, and analysis.		X									
3	Design, fabrication, and test techniques.		X	X								
4	Use of contemporary computer engineering analysis, design, and test tools.											X
5	Written and oral communication skills.							X				
6	Knowledge of ethical and professional responsibilities.						X					
7	Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.	X										
8	Knowledge of the benefits and the skills needed to engage in life-long learning.											X
9	Ability to be effective multidisciplinary team members.				X							
10	Skills to be an independent learner while knowing when to seek help.									X		
11	Knowledge of the role of Air Force engineering officers in our global society.								X			
12	Knowledge of contemporary social, political, military, and engineering issues.										X	

3.3 The Assessment of Program Curricular Outcomes

As seen in the Computer Engineering assessment process flow chart, Figure 2, the assessment of Program Curricular Outcomes (lower half of the diagram) is based on course assessments, division assessments (facilities and faculty, discussed in later sections), and some supporting items (Fundamentals of Engineering exam, exit survey, and skills review). The vast majority of the data used to assess cadet attainment of Program Curricular Outcomes comes from course assessments, with the Fundamentals of Engineering Exam, Skills Review and Exit Survey used to validate those results. The contributions of each of these items to Program Curricular Outcomes assessment, and their defined success criteria, are discussed in this section.

3.3.1 Program Curricular Outcomes Assessment Using Course-Based Objectives

The primary means of measuring whether cadets are achieving the stated Program Curricular Outcomes is based on a *course assessment* process consisting of three major steps:

- Presenting a Course Briefing before a semester starts
- Teaching the course and collecting data throughout a semester
- Accomplishing a Course Assessment Report at the end of a semester.

This process, illustrated in Figure 3, is based on well-defined, configuration-controlled Course Assessment Plans (CAPs). These documents (one for each major's course in the program curriculum) define the course goal, the (measurable) course objectives, the means by which each objective is assessed, and the objective's associated success criteria.

Course Assessment Plans were created and refined over a period of two years to provide a record of the course description, pre-requisites (by topic), goal, objectives, contribution to Program Curricular Outcomes, mechanism(s) for measuring performance (relative to objectives), and specific success criteria for that performance. In addition, course contributions to the ABET-defined engineering practice components (i.e., environmental, political, social, health and safety, economic considerations, manufacturability and sustainability, contemporary issues, and engineering ethics) are also included.

To illustrate how the program's course-based assessment works, consider a course in progress. Course Directors administer their course using the Course Assessment Plan for basic guidance. The Course Assessment Plan provides a roadmap, but does not include details of implementation (such as the number of lessons devoted to a topic, arrangement of topics, textbook, etc). This gives the Course Director flexibility in running the course, as long as the course objectives are adequately measured and satisfactorily accomplished. During the semester

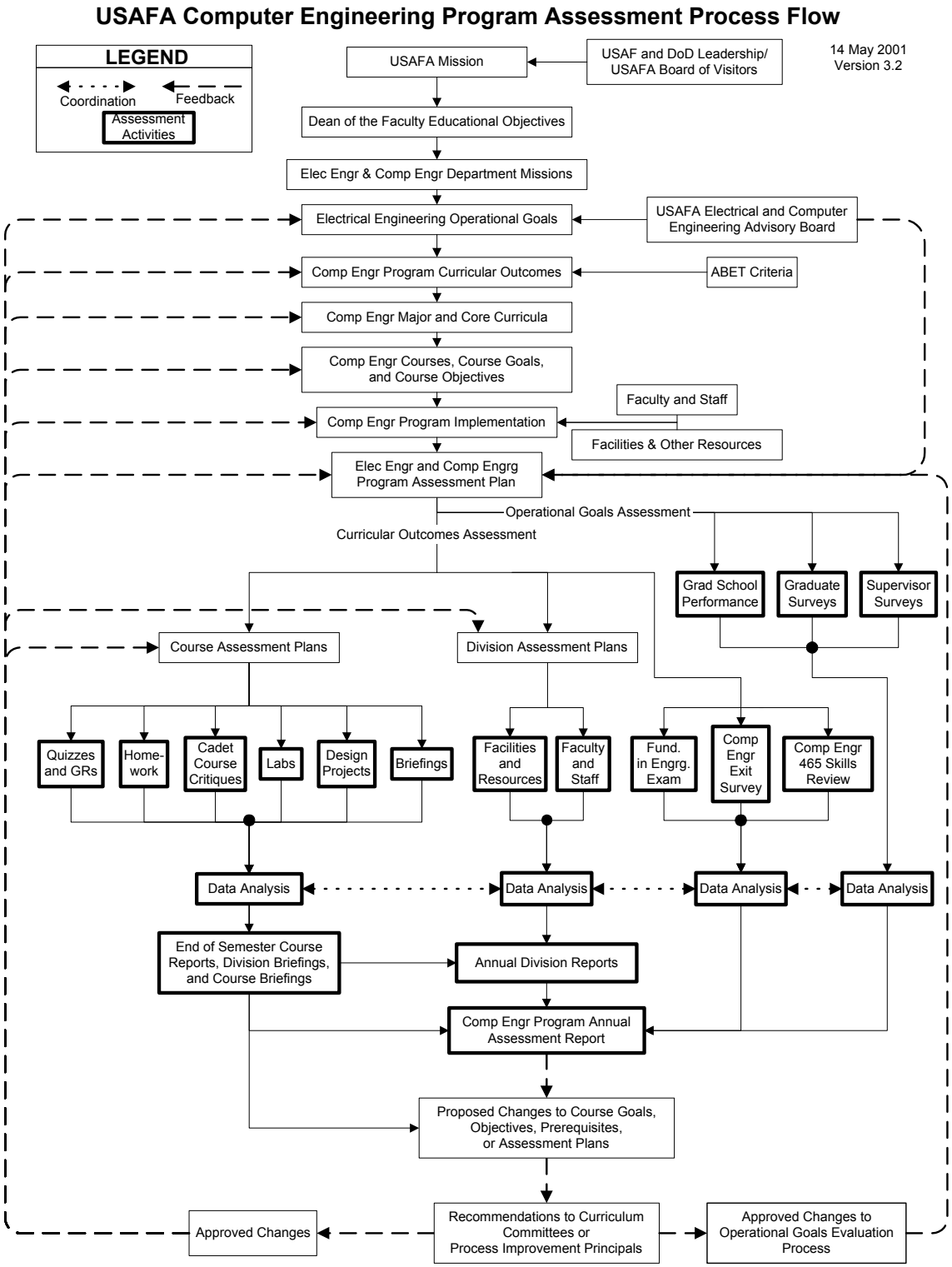

Figure 2. Computer Engineering Program Assessment Process Flow Chart

the Course Director maintains a log to record observations; this log offers qualitative observations to explain quantitative cadet-performance data.

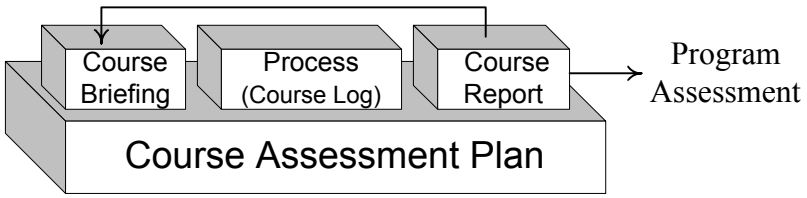

Figure 3. Computer Engineering Course Assessment Process Steps

Once a semester is completed, a Course Assessment Report is produced. The Course Assessment Report's main purpose is to address whether course objectives were met (thus providing data on whether Program Curricular Objectives are being accomplished). If there was a problem meeting a course objective, the Course Assessment Report defines the problem and recommends corrective action. This report must be read by the next offering's Course Director and addressed during the up-coming semester's Course Briefing to 'close the loop'. During that briefing (given to the entire department) the Course Director explains how the course will be administered, then describes any prior problems, planned corrective actions, and assessment methods to determine the viability of the proposed change.

At the end of each assessment year the Course Assessment Reports are summarized into the Computer Engineering Program Annual Assessment Report. If multiple course objectives supporting a single Program Curricular Outcome were not met, or were marginally met, the Computer Engineering Director of Assessment, in consultation with the Process Improvement Principals, determines the impact on the program. For example, if one course did not meet its laboratory skills objective, but all other courses supporting the corresponding Program Curricular Objectives met theirs', the Program Curricular Objectives would be assumed accomplished. Corrective action would then be taken to resolve the issues with the individual course's laboratory experience. Table 3 illustrates the relationship of objectives in the major's courses to the Program Curricular Outcomes.

In addition to the Course Directors' assessment of cadet-performance (to ensure they satisfy course objectives), cadets have the opportunity to give the Course Director feedback on how clearly they think objectives were presented. The mechanism for this feedback is an (anonymous) end-of-semester institutional Course Critique. These critiques contain questions related to quality-of-instruction, course-content, and department-specific issues. The critique's purpose is to give cadets the opportunity to offer their opinions without fear of retribution. Instructors see only composite results, and those only after grades have been assigned.

Table 3. Support of Computer Engineering PCOs by Course Objectives

PROGRAM CURRICULAR OUTCOMES / COURSE -- # OF OBJECTIVES	1 Application of the fundamental concepts of computer engineering to solve engineering problems.	2 Laboratory techniques including procedures, recording, and analysis.	3 Design, fabrication, and test techniques.	4 Use of contemporary computer engineering analysis, design, and test tools.	5 Written and oral communication skills.	6 Knowledge of ethical and professional responsibilities.	7 Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.	8 Knowledge of the benefits and the skills needed to engage in life-long learning.	9 Ability to be effective multidisciplinary team members.	10 Skills to be an independent learner while knowing when to seek help.	11 Knowledge of the role of Air Force engineering officers in our global society.	12 Knowledge of contemporary social, political, military, and engineering issues.
Signals & Systems Courses												
El Engr 231 -- 4	3	1	1	3	0	0	3	0	0	0	0	0
El Engr 332 -- 8	7	0	3	1	1	0	1	0	0	0	0	0
ENGR 311 -- 5	3	0	0	0	1	0	3	0	1	0	0	0
Totals	13	1	4	4	2	0	7	0	1	0	0	0
Digital Systems Courses												
El Engr 281 – 9	6	5	4	4	1	0	1	0	0	0	0	0
El Engr 382 – 8	6	3	3	6	2	0	3	0	0	0	0	0
El Engr 383 – 7	3	2	5	1	1	0	1	0	0	0	0	0
El Engr 485 -- 4	4	0	1	3	2	0	1	0	0	0	0	3
Totals	19	10	13	14	6	0	6	0	0	0	0	3
Electronic Systems Courses												
El Engr 321 -- 5	4	1	4	2	1	0	2	0	0	2	0	0
El Engr 322 -- 7	5	2	2	1	1	0	0	0	0	0	0	0
Totals	9	3	6	3	2	0	2	0	0	2	0	0
Computer Science Courses												
Comp Sci 110 – 8	4	2	5	1	1	2	5	1	0	0	1	2
Comp Sci 201 -- 10	3	0	1	1	0	0	10	0	5	0	0	0
Comp Sci 225 -- 6	4	0	0	1	0	2	5	3	1	1	1	0
Comp Sci 359 – 9	8	9	0	0	0	0	7	0	0	4	0	0
Comp Sci 380 – 6	0	2	1	0	0	0	6	2	0	2	0	0
Comp Sci 467 -- 9	7	1	2	2	3	4	3	2	1	2	3	4
Comp Sci 483 -- 6	5	1	4	2	0	0	6	0	0	0	0	1
Totals	31	15	13	7	4	8	42	8	7	9	5	7
Sr Seminar and Design Project Courses												
Comp Engr 405 -- 6	0	0	0	0	0	5	0	2	0	0	5	2
Comp Engr 465 -- 7	7	2	5	2	2	1	1	1	1	0	0	0
Comp Engr 466 -- 5	5	0	3	2	1	0	2	0	1	0	0	3
Totals	12	2	8	4	3	6	3	3	2	0	5	5
Program Totals	84	31	44	32	17	14	60	11	10	11	10	15

The list of current Course Assessment Plans can be found in Attachment C of the "Assessment Plan for Electrical Engineering and Computer Engineering Programs." Course Assessment Reports are completed at the end of the semester using the Course Assessment Report Template. Course Briefings are prepared and presented prior to the start of a semester using the Course Briefing template. All of these documents are available via links through the on-line version of the "Assessment Plan for Electrical Engineering and Computer Engineering Programs", which is accessible by the program's faculty.

3.3.2 Fundamentals of Engineering Exam Support of Program Curricular Outcomes Assessment

Results from the Fundamentals of Engineering (FE) exam are used as an objective validation of the course-assessment results. Although taking the exam is not mandatory, cadets are encouraged to take it, and assessment funds are made available to cover the exam cost. Results for each subject area are analyzed and compared to institutional, state, and national norms when possible.

3.3.3 Comp Engr 465 Skills Review Support of Program Curricular Outcomes Assessment

Beginning in 2003, all Computer Engineering majors will take a comprehensive skills review exam during their capstone design course, Comp Engr 466. These results will also serve to objectively validate course-assessment findings. The results will be collected and stored as part of the Comp Engr 466 course data in accordance with the respective Course Assessment Plan. Cadet motivation to perform up to their potential is provided because the outcome forms part of their course grade.

3.3.4 Comp Engr Major's Exit Survey Support of Program Curricular Outcomes Assessment

All Computer Engineering majors complete a Computer Engineering Major's Exit Survey during their final semester's capstone design course (Comp Engr 466). Survey results are 'mapped' to Program Curricular Outcomes to provide a subjective means of validating the course assessment process. The direct relationship of Exit Survey questions to Program Curricular Outcomes is shown in Table 4. The Exit Survey itself can be accessed on-line via links found in the "Assessment Plan for Electrical Engineering and Computer Engineering Programs".

Table 4. Support of the Computer Engineering PCOs by the Computer Engineering Major's Exit Survey

PROGRAM CURRICULAR OUTCOMES / SURVEY QUESTIONS	Application of the fundamental concepts of computer engineering to solve engineering problems.	Laboratory techniques including procedures, recording, and analysis.	Design, fabrication, and test techniques.	Use of contemporary computer engineering analysis, design, and test tools.	Written and oral communication skills.	Knowledge of ethical and professional responsibilities.	Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.	Knowledge of the benefits and the skills needed to engage in life-long learning.	Ability to be effective multidisciplinary team members.	Skills to be an independent learner while knowing when to seek help.	Knowledge of the role of Air Force engineering officers in our global society.	Knowledge of contemporary social, political, military, and engineering issues.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1-2	X											
3-7		X										
8-12			X									
13-14				X								
15-16						X						
17-21							X					
22-28								X				
29-33									X			
34-36										X		
37-38											X	
39-44												X
45-46					X							

3.4 Assessing Program Curricular Outcomes Achievement

The "Assessment Plan for Electrical Engineering and Computer Engineering Programs" has been in use for the past two years, and the Computer Engineering program has now produced two graduating classes. The assessment results for the first of those years, academic year (AY) 2000-2001, are contained in this report. The assessment of AY 2001-2002 data is presently underway, and will be available during the accreditation visit. Data from institutional Course Critiques is available from more than two years ago, so it is included to illustrate that the program has had stated objectives, and to show assessment has taken place, for several years.

3.4.1 The Use of Course-Objective Assessments to Evaluate Program Curricular Outcomes Achievement

The basis for Computer Engineering program assessment is satisfactory achievement of individual Course Objectives. One method the program has to validate the clarity of those objectives is to analyze cadets' response to a related question on institutional course critiques that are administered at the end of each semester. This response is reviewed for every course, every semester, and the course is flagged if the cadets' responses fall below 4.0 (Slightly Agree). Averages for Electrical Engineering and Computer Science courses offered over the past 4-1/2 years are shown in Table 5. These results indicate that the cadets understand the objectives established for each course.

Table 5. Cadet Feedback on Clarity of Course Objectives

	Fa 97	Sp 98	Fa 98	Sp 99	Fa 99	Sp 00	Fa 00	Sp 01	Fa 01
EE Courses	4.10	4.47	4.63	4.29	4.76	4.43	4.56	4.36	4.71
CS Courses	4.11	4.16	4.27	4.11	4.20	4.31	4.37	4.54	4.39

Another question on the end-of-course critique provides cadet feedback on the degree to which courses achieve their objectives. The response to this question is also reviewed every semester, and again a course is flagged for review if cadet scores are below 4.0 (Slightly Agree). All courses for the past 4-1/2 years were above this minimum, with an average of each year's results shown in Table 6. These results show that cadets agreed their courses were not only based on objectives, but those objectives were met by the course in that term.

Table 6. Cadet Feedback on the Degree Courses Met Stated Objectives

	Fa 97	Sp 98	Fa 98	Sp 99	Fa 99	Sp 00	Fa 00	Sp 01	Fa 01
EE Courses	4.20	4.53	4.84	4.55	4.91	4.59	4.75	4.48	4.84
CS Courses	4.25	4.27	4.37	4.22	4.29	4.37	4.49	4.62	4.52

The final table in this section, Table 7, summarizes the raw number of course objectives (in each course area, and in total) that relate to a particular Program Curricular Objective, and shows the percentages of those course objectives that were successfully achieved in AY 2000-2001. As described in Section 8 (Program Criteria), and previously seen in Table 3 of this section, the course areas and their associated courses are: Signals and Systems (El Engr 231, 332, Engr 311); Digital Systems (El Engr 281, 382, 383, 485); Electronic Systems (El Engr 321, 322); Computer Science (Comp Sci 110, 201, 225, 359, 380, 467, 483); and Senior Seminar and Design Project (Comp Engr 405, 465, 466). Four

of these areas (Signals and Systems, Digital Systems, Electronic Systems, and Computer Science) come under the control of the program's administrative Divisions. Administration of the fifth area (Senior Design Project and Seminar) rotates every 2 years between the Department of Computer Science (Computer Engineering Division) and the Department of Electrical Engineering (Computer Systems Division).

Based on the total percentages of successfully-achieved course objectives (shown in the bottom row of Table 7) all Program Curricular Outcomes appear to have been successfully achieved in AY 2000-2001 (subject to validation by the other assessment data sources). The lowest percentage of course objectives (related to a particular Program Curricular Outcome) that were successfully achieved is 81.82%, which is above the established program success criteria of 80%.

The AY 2001-2002 assessments will be completed in August, 2002, with results available during the evaluation visit. As a result, that data is not included in this document.

Table 7. AY 00-01: Percentages of Successfully-Achieved Computer Engineering Program Course Objectives Relative to the Program Curricular Outcomes They Support

PROGRAM CURRICULAR OUTCOMES / COURSE OBJECTIVES	Application of the fundamental concepts of computer engineering to solve engineering problems.	Laboratory techniques including procedures, recording, and analysis.	Design, fabrication, and test techniques.	Use of contemporary computer engineering analysis, design, and test tools.	Written and oral communication skills.	Knowledge of ethical and professional responsibilities.	Breadth and depth of knowledge and skills in electrical engineering, computer science, mathematics, and other	Knowledge of the benefits and the skills needed to engage in life-long learning.	Ability to be effective multidisciplinary team members.	Skills to be an independent learner while knowing when to seek help.	Knowledge of the role of Air Force engineering officers in our global society.	Knowledge of contemporary social, political, military, and engineering issues.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Signals & Systems, Course Objectives/PCO	13	1	4	4	2	0	7	0	1	0	0	0
Course Objectives Achieved (%)	100.00	100.00	100.00	100.00	100.00	N/A	100.00	N/A	100.00	N/A	N/A	N/A
Digital Systems, Course Objectives/PCO	19	10	13	14	6	0	6	0	0	0	0	3
Course Objectives Achieved (%)	94.74	100.00	92.31	92.86	83.33	N/A	100.00	N/A	N/A	N/A	N/A	100.00
Electronic Systems, Course Objectives/PCO	9	3	6	3	2	0	2	0	0	2	0	0
Course Objectives Achieved (%)	100.00	100.00	100.00	100.00	100.00	N/A	100.00	N/A	N/A	100.00	N/A	N/A
Computer Science, Course Objectives/PCO	31	15	13	7	4	8	42	8	7	9	5	7
Course Objectives Achieved (%)	90.32	93.33	100.00	85.71	100.00	75.00	92.86	75.00	85.71	88.89	80.00	100.00
Sr Project/Seminar, Course Objectives/PCO	12	2	8	4	3	6	3	3	2	0	5	5
Course Objectives Achieved (%)	91.67	100.00	87.50	75.00	100.00	100.00	66.67	100.00	100.00	N/A	100.00	80.00
Total # Program Course Objectives	84	31	44	32	17	14	60	11	10	11	10	15
Course Objectives Achieved (%)	94.05	96.77	95.45	90.63	94.12	85.71	93.33	81.82	90.00	90.91	90.00	93.33

3.4.2 Results from the Fundamentals of Engineering Exam

The results for the program's first graduating class (2001) are currently unavailable (due to the cadets taking the exam along with University of Wyoming students, and the inability of that institution to identify our cadets in their composite results). We hope to have the details of our cadets' performance available by the time of the visit.

3.4.3 Results from the Computer Engineering Skills Review

The Computer Engineering Skills Review will be administered for the first time in AY 2002-2003. As a result, no data exists for the classes of 2001 or 2002.

3.4.4 Results from the Computer Engineering Major's Exit Survey

All eight graduating Computer Engineering majors responded to the survey in 2001. Table 8 presents the results, showing that the cadets were satisfied with their educational experience, as defined by the Program Curricular Outcomes. (A 'G' stands for 'green', the indicator assigned to a satisfactorily-achieved objective.) The report scale for survey questions ranges from 1 (Strongly Disagree) to 6 (Strongly Agree). Any average of less-than 4.0 (slightly agree) for questions related to a particular Program Curricular Outcome would be a cause for concern that the Project Improvement Principles would address. Results of the 2002 survey will be available during the accreditation visit.

Table 8. Results of the 2001 Computer Engineering Major's Exit Survey, as Related to Program Curricular Outcomes Assessment

Survey Questions \ PCOs	1	2	3	4	5	6	7	8	9	10	11	12
1-2	G											
3-7		G										
8-12			G									
13-14				G								
15-16						G						
17-21							G					
22-28								G				
29-33									G			
34-36										G		
37-38											G	
39-44												G
45-46					G							

3.4.5 Program Curricular Outcomes Assessment Conclusion

Integrating and analyzing the data from the assessment data sources presented above (Course Objectives Assessment and Comp Engr Majors Exit Survey), it is clear that the USAF Academy Computer Engineering Program achieved its Program Curricular Outcomes in AY 2000-2001. We expect similar results for AY 2001-2002 based on preliminary assessment; final results will be available during the evaluation visit.

3.5 Changes Made to Improve the Program

The Department of Electrical Engineering and Department of Computer Science have had continuous process-improvement programs for many years. Prior to the increased emphasis on formal documentation that started in 1997, the two departments used a simpler two-fold approach to ensure courses met their stated objectives. First, the course director compiled a Course Assessment Report after each offering of the course. Among other things this Course Assessment Report identified any deficiencies and recommended corrective action. Second, the next course director (often the same faculty member) read the Course Assessment Report as they prepared their (mandatory) Course Briefing for the course's next offering. The new Course Director made any changes they considered necessary to address problems described in the previous-offering's course report. With this explanation, Table 9 presents some of the changes made to improve the program based on comments from Course Assessment Reports and Course Briefings. More detail on any of these items is available in the appropriate Reports and/or Briefings.

Table 9. Examples of Assessment-Driven Changes Implemented to Improve the USAF Academy Computer Engineering Program

Change	Reason(s)	Course(s) Involved
2002		
Full Lab write ups	Tried having cadets write parts of a lab in EE 281, but they did not carry lessons from previous write ups to the next lab.	El Engr 281
Drop Comp Sci 380 from Comp Engr Major. Added more Hours for Comp Engr 466	The senior design sequence lacked the time for cadets to do a meaningful design project that combined hardware and software. (The content of CS380 used by Comp Engr majors was transferred to CS220, see below.)	Comp Engr 465, CS380
Replaced Comp Sci 201, 225, and 380 with Comp Sci 210 and 220. Changed remaining Comp Sci course sequence	To provide more contact hours for computer programming and to better balance semester hours of the majors courses.	Continuing: Comp Sci 380, 483, 359, and 467 Old: Comp Sci 201, 225 New: Comp Sci 210, 220
2001		
Lab Notebook Focus	Ensure cadets adequately and consistently documented lab work.	El Engr 281, 382
Computer System Division Modernization	Different processor and technologies now used due to changing technologies and "C" programming language incorporated.	El Engr 382, 383
2000		
Eliminate lab sequence and incorporate lab into electronics courses	- El Engr 352 course critiques showed students considered lab content separate from relevant classroom instruction. - Level of conceptual reinforcement of electronics required improvement.	Old: El Engr 350, 351, 352, 341, 342 New: El Engr 321, 322
Revamped the Information Warfare Course to be more practical and hands-on	- A theoretically-based course had little value -- Air Force Information Warfare community requested we take part in a cyber defense exercise.	Comp Sci 438 (An optional course)

3.6 Lessons Learned During Assessment Process Development and Improvement

The faculty of the Computer Engineering program has learned many lessons as the formal assessment process for the program has progressed. Here is an informal list of a few of those lessons to illustrate that the faculty is dedicated to continuous process improvement:

- Faculty must be involved from the beginning. Involving faculty in the development of goals, outcomes, and objectives gives them ownership and increases their participation in the annual assessment process.
- Writing measurable objectives is an iterative process. Course Directors were trained on the course objective writing process at an annual offsite. They were involved in an interactive activity for practice, but when it was time to write objectives for their courses, those objectives were not always measurable.
- It is important to fully incorporate assessment activities into each individual's standard operating procedures. All faculty expressed a concern about adding assessment activities to their current workloads. Their involvement and feedback allowed all involved to evaluate their current procedures (including course activities, planning, and additional duties) to eliminate redundant activities that do not support their objectives. Incorporating assessment procedures into standard procedures also helped faculty members understand their role and responsibilities in the annual assessment process.
- Templates greatly assisted the reporting process, saving time compared to existing practices. Faculty feedback helped fine-tune those templates.
- It is important to resist the urge to constantly improve the templates. It is frustrating for the user and adds unwelcome administrative overhead to find and use the most current template.
- Standardized evaluations are necessary to compare assessment results, but allowing flexibility for the faculty to determine their overall assessment (formulae, tables, etc) is important for instructor autonomy. It is critical to have the Course Directors specifically state whether or not course objectives were met. Without a definitive answer, the Division Chief and Director for Assessment must re-read each report to make this determination.
- It is easy to collect and evaluate data, but the important thing is to use that data to improve the program.
- Faculty and staff must be periodically briefed/updated on the results of the annual assessment process or they may become discouraged and feel their work is not being used. Senior program leaders must close the loop with their personnel.

3.7 Supporting Materials Available for Review by ABET Visitors

The following materials will be available for ABET visitors:
The following materials will be available for ABET visitors:

- Updated Tables
- Updated Faculty Vitae
- Electrical Engineering Program Annual Assessment Report for AY 2000-2001
- Electrical Engineering Program Annual Assessment Report for AY 2001-2002
- Supporting data for Program Annual Assessment Reports
- Program Curricular Outcomes Binders
    - One (1) binder per outcome
    - Summary of curricular requirements (e.g. applicable courses, assignments)
    - Samples of cadet work to support each outcome.
- Course Binders
    - One (1) binder per course
    - Course Assessment Plan
    - Course briefing for previous offering
    - Handouts for previous offering
    - Samples of cadet work for previous offering
    - Course Assessment Report for previous offering
- Program Assessment Plan and all linked documents
    - Program Assessment Schedule
    - Division Assessment Plans
- Electrical and Computer Engineering Advisory Board details (including minutes)
- Access to internal and external web sites
- Dean of Faculty Operating Instructions
- All Departmental Operating Instructions
- 2000-2001 USAF Academy Assessment Catalog
- 1999 Institutional Self Study
- Faculty Handbook
- Advisor Handbook
- New Faculty Orientation Materials
- ABCs of Academics (Handout for Cadets)
- 2001-2002 and 2002-2003 Catalog
- 2001-2002 and 2002-2003 Curriculum Handbook

4. Professional Component

Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.

The professional component must include:
(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline
(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study
(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Cadets are well prepared for engineering practice by the thorough, well-rounded educational experience at the USAF Academy. All Computer Engineering cadets are required to take an extensive core academic curriculum consisting of courses from four different divisions: Basic Sciences, Social Sciences, and Humanities, and Engineering. Courses in Military Studies and Physical Education are also required of every cadet. First, the program's professional component is described to illustrate how it meets the curricular requirements. Following that is a description of the design curriculum, and how it incorporates engineering standards and realistic constraints.

4.1 Curriculum

The Computer Engineering curriculum meets or exceeds the minimum requirements for all ABET Criterion 4 standards in math, basic sciences, experimental experience in math and basic sciences, engineering science, engineering design, and general education. A typical three-semester-hour course meets for one 50-minute period every other day for 42 lessons, and requires 100 minutes per lesson of outside work. One academic year contains 34 weeks of instruction, exclusive of final examinations. For comparison purposes, sixteen semester hours equal one-half year of study.

4.1.1 Math and Basic Sciences

Cadets in the Computer Engineering program complete a total of 33 semester hours in math and basic sciences (just over 1 year of study). Breadth is achieved by required courses in calculus, probability and statistics, physics, chemistry, and biology. These courses in the core program have been carefully chosen by the Academy to give all cadets a broad education and the tools to be complete military officers. Depth in mathematics is achieved by requiring two calculus courses, and an additional course in differential equations. Experimental experience is developed in four of the required science courses; two in physics and two in chemistry. A listing of these courses is provided in Table I-1 and course descriptions may be found in the USAF Academy 2002-2203 Curriculum Handbook. The Curriculum Handbook is the Academy's official curriculum document and contains the most recent information available.

4.1.2 Engineering Topics

Cadets in the Computer Engineering program complete a total of 66 semester hours in engineering topics (over 2 years of study). Breadth is achieved by required core courses in Engineering Mechanics, Civil Engineering, Aeronautical Engineering, and Astronautical Engineering. The core program also includes a project-based engineering course currently taken in the senior year. However, as a result of an Academy-wide assessment of the core curriculum during the past year, this project-based course will be moved to the freshman year to motivate more cadets to consider majoring in an engineering discipline. Depth in engineering for the Computer Engineering program is well balanced among Electrical Engineering, Computer Science, and Computer Engineering courses. A listing of these courses is also provided in Table I-1, with course descriptions provided in Appendix I-B as well as the USAF Academy Curriculum Handbook.

4.1.3 General Education

Cadets in the Computer Engineering program complete a total of 45.0 semester hours in the humanities and social sciences (1.31 years of study). Breadth is achieved by required courses in English, foreign language, history, behavioral science, and philosophy (in the humanities), economics, law, management, and political science (in the social sciences). Depth in humanities and social sciences is achieved by requiring three courses in English, two in a foreign language, two in political science, and two in History.

4.2 Design Experience

The philosophy of the Computer Engineering program is to infuse the entire curriculum with opportunities to practice the design process. Many of the required Electrical Engineering and Computer Science courses have a significant percentage of engineering-design content. While the Electrical Engineering courses use a laboratory component designed give the cadet hands-on practice applying the theory they have learned, the Computer Science courses require cadets to implement their algorithm designs using various programming languages. The curriculum culminates in a two-course major design experience.

Cadets are introduced to engineering design in the sophomore year. As they learn basic analog and digital circuit design in El Engr 231, Electrical Circuits and Systems I, and El Engr 281, Introductory Digital Systems, they are required to design simple circuits to meet specifications. Examples include operational amplifier circuits, first-order filters, and sequential state machines. Many sophomores also take Engr 311, Electrical Power Systems, which includes power system design as well as AC and DC motor design assignments. In their computer science courses they learn programming skills and algorithm design in Comp Sci

201, Programming in Ada, Comp Sci 225, Fundamentals of Computer Science, and Comp Sci 380, Algorithms and Data Structures.

During the junior year, cadets gain experience in three areas of emphasis in the Electrical Engineering curriculum: electronics, signal and systems, and computer systems. In El Engr 321, Electronics I, cadets receive formal instruction in the design process which is reinforced through two laboratory exercises on bipolar and MOS transistor amplifiers. In El Engr 322, Electronics II, cadets expand this design experience through laboratories on differential pair amplifiers, linear amplifiers with feedback and CMOS digital circuits. Both parametric and block circuit design are emphasized. Our cadet's basic competence in the design of electronic circuits is assessed in this course. Analog circuit design is continued in El Engr 332, Electric Circuits and Systems II, where cadets design resonant circuits and higher-order filters. El Engr 382, Microcomputer Programming, includes lab exercises in which cadets design software and circuits as they study various aspects of the Motorola 68HC12 microcontroller (interrupts, timing, I/O ports, etc.) that culminates in the development of a tethered robot navigating a maze. That knowledge is carried forward and applied in El Engr 383, Microcomputer System Design I, in which cadets augment the on-board capabilities of the 68HC12 by designing and adding subsystems, such as additional memory. This course culminates with each cadet choosing and executing a project that requires both hardware and software design. The design of operating systems is covered in some depth in Comp Sci 483, Operating Systems.

In the fall of the senior year Comp Engr 465, Systems Analysis and Design I, begins a two-semester senior design process. In this course all the senior cadets in the major begin preliminary design work on a team-based project. Topics involve requirements definition as well as high-level block diagram design for both hardware and software. The follow-on course, Comp Engr 466, Systems Analysis and Design II, is taken in the spring of the senior year. The project is completed during this course. Throughout Comp Engr 466 the focus is to prepare cadets for engineering practice in three main ways: first, they have responsibility for design, fabrication and testing of a major project; second, they are required to practice technical communication skills in the form of formal briefings at three key points in the project; and third, they are required to estimate and plan their activities to implement a realistic schedule. In addition, they are required to write a comprehensive technical report, with a draft of the report turned in after each major briefing. Over the past 2 years the senior design project has been focused on certain subsystems associated with a man-portable, unmanned aerial vehicle. This system will eventually be used by US Special Forces troops for battlefield surveillance purposes.

As a junior or senior Computer Engineering majors also take an elective course to facilitate more depth in an Electrical Engineering or Computer Science topic. These courses all delve into design-related topics at some level. However, the program does not rely on any of these courses to ensure it meets minimum program requirements.

The program's approach of continually involving cadets in laboratory and design work throughout their program, coupled with a year-long design experience at program's end, gives the cadets practice in the main aspects of engineering. As theory is presented in a class, cadets apply this basic knowledge to homework problems, laboratories, and computer exercises at both the analysis and synthesis levels. A main objective of the program's design experience is to improve the cadets' ability to frame and resolve ill-defined problems. As cadets progress through the program, the problems they solve are progressively less-defined. Then, in their capstone senior design courses, cadets are required to put into practice the knowledge and skills they have acquired.

4.3 Coverage of Engineering Standards and Realistic Constraints

In the Computer Engineering program the assessment process requires that the Course Assessment Plan for each course document coverage of the professional component: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political considerations. Any given course may cover some, all, or none of these considerations, but as part of the Course Assessment Plan review process, the Process Improvement Principals ensure adequate coverage of all these topics across the curriculum.

During course briefings, held before the start of each semester, Course Directors describe in detail how they plan to implement the Criterion 4 considerations outlined in their Course Assessment Plan. At the end of each semester, Course Directors document in their Course Assessment Reports how their course actually covered each Criterion 4 topic. A summary of the actual coverage is then documented in the program's Annual Assessment Report.

Here are some examples of Criterion 4 coverage in the Computer Engineering program. In the electronics courses (El Engr 321/322), Criterion 4 issues are discussed related to integrated circuit manufacturing, and its impact on society. In the digital courses (El Engr 281/382/383/485), Criterion 4 issues related to choice of logic families for a design, and impact of computer technology (such as microprocessors and robots) on our world are included. Many of these issues are also included in Comp Engr 465/466, the capstone design course sequence.

4.3.1 Preparation for the Practice of Engineering

Through the program's carefully-designed curriculum, cadets gain breadth-of-knowledge in the humanities, social sciences, basic sciences, and engineering, as well as breadth and depth of knowledge in Computer Engineering. They are introduced to problem-solving processes in theoretical courses, then required to practice them in the design component of the curriculum. Early in their education at the USAF Academy they are required to apply their problem-solving skills to a wide variety of problems that are well-defined, but those

problems (intentionally) become less-and-less defined as they progress toward graduation. This multi-faceted approach forms the basis for preparing USAF Academy Computer Engineering majors for the practice of engineering

4.3.2 Honor, Ethics, and Professionalism

Engineering ethics are informally covered in several courses (as outlined in the Course Assessment Plans) to help the cadets understand ethical issues specific to engineering. A formal exercise occurs in Comp Engr 465, where engineering ethics are discussed as part of a case study. At key points in the capstone design experience (Comp Engr 465/466) cadets are required to formerly address all of the Criterion 4 issues as related to their project. This is accomplished via both briefings and technical reports.

In addition to the study of ethics in engineering described above, all cadets are required to take a course in ethics as part of the general core curriculum. Philosophy 310, Ethics, taught by the Department of Philosophy provides a study of major moral theories and their application to contemporary moral problems with special emphasis on the moral problems of the profession of arms. Since "Integrity First" is one of the core values of the US Air Force, the officer candidates at this institution are required to practice on a daily basis the ethical lessons taught in class. They are expected to do this not only in the academic environment, but also in the athletic and military-training environments.

The concepts of ethics and professionalism are inseparable as taught to cadets at the US Air Force Academy. "We will not lie, steal, or cheat nor tolerate among us anyone who does" are the Cadet Honor Code principles used to establish and nurture the behavioral standards required throughout a cadet's ethical development. This honor code is the subject of 37 hours of formal training during a cadet's four years at the USAF Academy. All new faculty members are also introduced to the Honor Code and Honor System during a week long new-instructor orientation course. In addition, all academic departments have mandatory annual briefings presented by the officers and cadets responsible for maintaining the integrity of the honor process.

4.3.3 Process Management

Social and economic considerations of engineering practice are studied as part of the extensive social sciences core curriculum. As an example, Management 210, Introduction to Management, covers many aspects of engineering economy. This survey course contains engineering economics topics such as alternative decision making, economic decision making, opportunity costs, alternative manufacturing decisions, process costing, economic life, and management information systems.

In Engineering 410, a project-based engineering design course required of all cadets, they gain practical experience in both social and economic implications of engineering. Each class forms a company that "competes" for an Air Force contract. The semester is spent performing analysis, design, fabrication, and testing of their 'product'. During the design process they learn that trade-offs between cost, performance, and time must be made continuously, as each section is limited in the money and resources available to complete its task. Social and government restrictions play a large role in the projects because they affect either Air Force or local community affairs. Instructors from all engineering departments are assigned to teach the course.

As a result of a recent Academy-wide core curriculum assessment, Engineering 410 will be replaced with a freshman year course which will introduce cadets to all the engineering disciplines. This new course will not focus on project management (money, fabrication, system integration, etc); however, the Computer Engineering program's two-course senior design project (Comp Engr 465/466) has been expanded from 4.5 to 6 semester hours. This change allows cadets more time to learn and practice project management tasks directly related to the Computer Engineering discipline.

4.3.4 Cadet Summer Research Program

The Cadet Summer Research Program (CSRP) is designed to enlighten cadets in their field of study by applying the knowledge they have gained to the solution of actual research problems. Working side-by-side with leading military, government, and civilian researchers cadets learn problem-solving and information-gathering skills which will help them to become more effective officers. Each year over 100 cadets from the USAF Academy, including Computer Engineering majors, participate in this program, which extends to over 70 locations worldwide. Treated as a five-week temporary duty assignment, the cadets also get a glimpse of the operational Air Force, allowing them to see the workings of a "real-life" engineering unit at a government institution. For those cadets who get the opportunity to participate, the Cadet Summer Research Program becomes a vital part of their academic and military educational experience.

The Cadet Summer Research Program is extremely competitive with high academic and military standards. The Computer Engineering program attempts to send about 30% of its majors each Summer. Although the Computer Engineering program is relatively new (only two classes have graduated), Computer Engineering majors have participated with Electrical Engineering majors at some of the following locations:

- Central Intelligence Agency, Power Sources Center
- Directed Energy Directorate, Air Force Research Laboratory, Kirtland AFB, NM
- 85th Test and Evaluation Squadron, Detachment 1, Tyndall AFB, FL

- Combat Air Forces Command and Control Systems Program Office, Electronic Systems Center, Hanscom AFB, MA
- Engineering Microtechnology Division, Lawrence Livermore National Laboratory, Livermore, CA
- Air Force Research Laboratory Sensors Directorate, Wright-Patterson AFB, OH
- Neutrino Science Center, Los Alamos National Laboratory, Los Alamos, NM

Upon their return, cadets are required to write a report outlining their project and experiences, as well as present a formal briefing to interested members of the Computer Engineering faculty. Previous projects have included topics such as:

- Thermal Protection of Weather Balloon Batteries Experiment
- Radar Test Range Instrumentation
- Power Requirements for Data Collection and Exfiltration System,
- Radio Frequency Particle Acceleration
- Theater Battle Management Core System
- Design and Fabrication of a Polymer-Based Electrostatic Microactuator
- Set-up and Use of Two LADAR Imaging Cameras

4.3.5 Student Chapters of the Institute of Electrical and Electronics Engineers (IEEE) and Association of Computing Machinery (ACM)

The Department of Electrical Engineering sponsors a student chapter of the Institute of Electrical and Electronics Engineers (IEEE). The student chapter recently sponsored a faculty-wide presentation by General (ret) Donald Kutyna, the country's lead investigator into the space shuttle Challenger accident, on "Engineering Ethics in Connection with Space Shuttle Challenger Disaster." The chapter also served as host to almost 200 students from more than 20 universities for the 2001 IEEE Region 5 Student Professional Activities Conference (S-PAC) and Student Design Contest. A total of 10 cadets from the USAF Academy participated in this conference. Field trips are taken each year to Air Force laboratories and local companies such as Dunlavy Audio Laboratories and United Technologies. A member of the Electrical Engineering department's faculty serves as the student-branch's faculty advisor.

The Department of Computer Science sponsors a student chapter of the Association for Computer Machinery (ACM). The student chapter participates in yearly programming contests against other colleges. A member of the Computer Science Department serves as the chapter's faculty advisor.

4.3.6 Student Chapter of Tau Beta Pi

To encourage engineering excellence, and recognize the students who achieve it, the US Air Force Academy established a chapter of Tau Beta Pi, the National Engineering Honor Society on March 8, 1997. Prior to the installation of

Colorado Zeta (the USAF Academy Tau Beta Pi Chapter) the Engineering Division sponsored the USAF Academy Engineering Honor Society, which served as the Chapter's precursor.

4.3.7 Fundamentals of Engineering Exam

Seniors majoring in USAF Academy engineering programs are encouraged (but not required) to take the Fundamentals of Engineering (FE) exam. In the spring of 1996, an engineering division assessment committee surveyed cadets from all accredited majors to discover what would motivate them to take the FE exam. Results showed that faculty encouragement, Engr 402 (Professional Engineering Development), and funding were key issues.

It is the responsibility of Computer Engineering faculty advisors to encourage cadets to enroll in Engineering 402. This course is designed to prepare cadets for the Fundamentals of Engineering examination, and is managed by the Department of Civil Engineering. The course takes a multidisciplinary approach and includes reviews of engineering mechanics, mechanics of materials, electrical circuits, mathematics, fluid mechanics, thermodynamics, computer programming, chemistry, and engineering economics. Engr 402 is taught by instructors from across the Engineering Division.

Prior to the start of each Fall semester, during a (mandatory) back-to-school meeting, senior faculty members remind cadets entering their senior year of both the purpose and importance of the FE exam. At similar meetings with the sophomore and junior Computer Engineering majors, the faculty introduces the concept of engineering licensure, expecting that those cadets will hear the seniors discussing it. All faculty members are asked to discuss the exam during the school year, but especially at the beginning of the Spring semester (the term the exam is administered at the USAF Academy).

Engineering Division assessment funds are made available to cover the exam costs for majors in the USAF Academy's accredited engineering programs who choose to take the exam at the USAF Academy in the spring. As explained earlier, FE exam results are reviewed annually and incorporated into the program's Annual Assessment Report.

5. Faculty

The faculty is the heart of any educational program. The faculty must be of sufficient number; and must have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students. The faculty must have sufficient qualifications and must ensure the proper guidance of the program and its evaluation and development. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and registration as Professional Engineers.

The Computer Engineering program is an interdisciplinary offering that draws resources from both the Department of Electrical Engineering and the Department of Computer Science. They administer the program on a rotating basis, the details of which are outlined in a Memorandum of Agreement. The Program Head duties are currently the responsibility of the Department Head for Electrical Engineering, who will finish serving this two-year duty and turn the job over to the Department Head for Computer Science after the ABET accreditation visit in Fall, 2002. Since both departments are involved, both faculties will be described.

The Electrical Engineering Department has one permanent professor (Department Head), one Senior Military Professor, two professors, five associate professors, five assistant professors, three instructors, four laboratory technicians, and one secretary. Most faculty members are full-time employees, and they perform administrative duties in addition to teaching. Twelve of these faculty members are professional military officers, three are hand-picked full-time civilians, and two are part-time visiting professors. All have earned graduate degrees in Electrical or Computer Engineering (currently 82% of the department's faculty have earned Ph.D. degrees, the remaining having MSEE degrees). Each year the department invites one or two visiting professors to serve as members of the faculty. These visiting professors all have earned doctoral degrees and are well know in their respective discipline.

The Computer Science faculty is also composed of professional military officers and hand-picked civilian professors with graduate degrees in Computer Science, Operations Research, or Computer Engineering (currently 60% of the department's faculty have earned Ph.D. degrees, the remaining having MSCS degrees). The Computer Science department has one permanent professor (Department Head), one professor, two associate professors, nine assistant professors, seven instructors, one educational technician, one computer technician, and one secretary. All faculty members are full-time employees, and they perform administrative duties in addition to teaching. Of the twenty faculty members, two are long-term civilian members. In addition, each year Computer Science has one or two visiting professors as members of the faculty. These visiting professors are well know in their respective discipline. All have earned doctoral degrees.

This mix of faculty members brings backgrounds and interests in a wide variety of curricular areas to the program (see the Faculty Resumes in Appendix I-C of this document for more information on backgrounds and interests). There are sufficient faculty to implement both the Computer Science and Electrical Engineering portions of the curriculum and, in past cases of unexpected personnel changes, the faculty's senior leadership has approved and provided funds for temporary civilian instructors.

5.1 Adequacy of Faculty

The faculty of the Electrical Engineering Department typically numbers between 17 and 22 instructors, with 17 currently serving. On average, the department instructs 700 cadets per semester, resulting in a cadet to faculty ratio of approximately 41:1. Faculty members teach between two and four sections and class sizes are limited to 24 cadets. This results in a maximum ratio of 24 cadets per faculty member during lectures and laboratories. For laboratory intensive courses, the maximum number of cadets is between 8 and 15, thus lowering the cadet-faculty ratio to allow more interaction and technical assistance.

The faculty of the Computer Science Department numbers between 18 and 25 instructors, and currently has 20 instructors. On average, the department instructs 700 cadets per semester, resulting in a cadet-to-faculty ratio of approximately 35:1. Instructors teach between two and four sections with section sizes typically limited to 24 cadets.

These low cadet-to-faculty ratios are a cornerstone of the US Air Force Academy's philosophy of giving as much individual attention to each cadet as possible. When instructors are not in the classroom teaching, they are expected to be available to cadets for advising and help, giving cadets almost limitless access to instructors.

In addition to instruction, each faculty member associated with the Computer Engineering program serves as an academic advisor for an average of six-to-seven cadets from their principle major, and three-to-four computer and/or general engineering cadets. This small ratio allows excellent interaction between individual faculty and cadets. One to three faculty members from each department also serve as academic advisors to first year (freshmen) cadets who have not yet declared their major. Typically, each of these advisors handles about 30 cadets. However, since most of the first three semesters are taken up by courses required of all cadets, and those schedules are set by the Registrar before the cadet enters the Academy, there is little time actually spent (on average) advising each cadet.

Due to the small number of cadets in each section of a course (24 cadets maximum, fewer in laboratory-intensive courses), faculty-cadet interaction is maximized. Faculty members can interact, counsel, or assist cadets anytime they are not teaching. In addition to faculty, the Electrical Engineering department also has four full-time electronics technicians that assist instructors during any class period that involves laboratory experiments. The Department of Computer Science has one computer technician that aids instructors with computer lab setup and maintenance. This

significantly enhances the laboratory experience for cadets, allowing them to almost always receive immediate feedback on questions that may arise during the laboratory exercise.

As discussed earlier, the electrical engineering faculty is currently composed of 17 full-time members with 82% holding Ph.D. degrees and the remaining holding MSEE degrees. These individuals bring backgrounds and interests in a wide variety of curricular areas to the program, including analog and digital circuits, electronics, linear systems, microprocessors, electromagnetics, analog and digital communications, radar, instrumentation, computer architecture, signal processing, and optoelectronics. The Electrical Engineering portion of the Computer Engineering curriculum is divided into three areas: signals and systems, computer systems, and electronic systems. As faculty members leave for other assignments our departmental personnel system screens potential candidates to ensure there are no "holes" in any of these areas.

Also as discussed earlier, the computer science faculty is composed of 20 full-time members with 60% holding Ph.D. degrees and the remaining holding MSCS degrees. These individuals bring backgrounds and interests in a wide variety of curricular areas to the program, including software engineering, software analysis and design, programming languages, information assurance, information warfare, computer security, artificial intelligence, networks, operating systems, graphics, web-based design, and database design and application. The Computer Science Department has identified four areas of excellence in the department: Information Warfare, Computer Science Education, Operations Research, and Computer Engineering. As faculty members leave for other assignments our departmental personnel system screens potential candidates to ensure there are no "holes" in any of these areas.

In addition to their teaching and advising duties, computer engineering faculty members from both departments also serve on numerous Engineering Division, Basic Science Division, Faculty- and Academy-Wide committees, and advisory boards. These cover a number of different topics and faculty usually volunteer to participate. Typically, these activities do not require extensive amounts of time, and are generally supported during times when cadets are unavailable (lunch, military training, summer, etc).

5.2 Engineering and Teaching Experience

Assignment to the Academy for military members is voluntary and highly competitive; only officers with outstanding military and academic records are selected to serve on the faculty. On the civilian faculty side, assistant professors are selected and interviewed from a large pool of applicants. The typical military faculty member serves for three to four years, while civilian faculty serve on renewable, multi-year contracts (for more detail on the Civilian Faculty Program, see Appendix II, A-4).

The majority of military faculty members have at least six years of operational experience at the time of assignment to the Academy. They have served in engineering or technically-related jobs (research and development, industrial, test and evaluation, algorithm development, etc). Thus the program benefits from a constant influx of experienced engineers and computer scientists knowledgeable in the state-of-the-art and familiar with real engineering problems. Each year one-or-two military faculty members are selected to pursue doctoral degrees at top institutions around the country. These officers then return to the faculty later in their careers to provide even greater expertise and leadership to the program for (at least) four more years. Currently nine of the most senior leadership positions in Electrical Engineering are held by such "returning" faculty members, with four such positions in Computer Science.

As can be seen in Appendix I-C, Faculty Vitae, four Electrical Engineering and ten Computer Science faculty members have less than four years of teaching experience. Eight faculty members from Electrical Engineering and nine from Computer Science have five to ten years of experience, and five from Electrical Engineering and one from Computer Science have more than ten years teaching experience.

5.3 Professional Development

Each year, new faculty members participate in a comprehensive summer training program known as Faculty Orientation. In this program they learn about the Academy's mission, operations, cadet life, and a variety of effective teaching and learning styles. New faculty also assist in department-run summer academic sessions by preparing and delivering lectures, developing and grading exams, and attending educational seminars. A large part of Faculty Orientation is administered by the Faculty Development Division of the Academy's Center for Educational Excellence (DFE), with remaining program-specific activities run by individual departments.

During the academic year, classroom teaching performance is monitored by senior faculty members as well as by peer-auditing, and constructive feedback is provided to help insure a high quality of education. Educational seminars, provided by DFE or prepared by department faculty members, address such issues as test design, grading, educational technology, etc. and occur throughout the year. Attendance at many of these seminars is mandatory for first-year faculty. The result of these efforts is a very cohesive, motivated, and professional faculty dedicated to undergraduate education. During each semester, the faculty attends a number of departmental seminars presented by program faculty members. These typically involve presentations on current research projects, or other items of interest.

Teaching loads are arranged to leave time for research and faculty professional development, as appropriate to the teaching-oriented mission of the USAF Academy. Some examples of recent professional development efforts include innovation in classroom and laboratory techniques, participation in course directors' workshops,

participation and attendance at local and national American Society for Engineering Education (ASEE) annual conferences, local Institute for Electrical and Electronics Engineers (IEEE) and Association for Computing Machinery (ACM) section meetings, and engineering projects (consulting) for other Air Force agencies. A sabbatical program is in place for civilian instructors and sequential-tour officers (officers serving in an extended military assignment beyond the typical four years). In addition, civilian instructor contracts are reviewed and are typically renewed every three years. USAF Academy Regulation 36-3, available with the course materials at the time of visit, contains details for these programs.

In the Department of Electrical Engineering, two full-time faculty members and one visiting civilian professor have been licensed professional engineers for many years. In addition, during the past six years, seven faculty members have successfully passed the Professional Engineering exam, and all are now licensed professional engineers.

5.4 Participation in Professional Societies

Computer Engineering faculty members are active in a variety of professional organizations including the Institute of Electrical and Electronics Engineers (IEEE), the American Society for Engineering Education (ASEE), the Association for Computing Machinery (ACM), the Armed Forces Communications and Electronics Association (AFCEA), the International Society for Optical Engineering (SPIE), and the Rocky Mountain Biomedical Society (RMBS). In the past six years, Electrical Engineering department members have served as IEEE officers (vice-char and chair of the Pikes Peak Area), served on the RMBS board of directors, served on the IEEE national licensure committee for professional engineer certification, and visited other campuses as ABET evaluators. Faculty members have also authored papers in a variety of professional publications, and served as session chairs at technical and educational conferences and symposia.

Every member of the program's faculty is highly encouraged to attend at least one professional conference or activity per year (IEEE, ASEE, ACM, short course, etc.) to help stay abreast of technological and educational advancements.

5.5 Guidance, Evaluation, and Development of the Program

As explained in the section on Program Curricular Objectives, the entire program faculty takes an active role in the continued development and improvement of the computer engineering program at the USAF Academy. Each member participates in the review of courses in their areas of specialty. Course content and administration for an upcoming term is reviewed by faculty members from both departments during formal course briefings. These course briefings are presented by the course director (lead instructor for the course) and cover such areas as syllabus, grading criteria, textbook, lesson schedule (by topic), lessons-learned from previous offerings, and any other information pertinent to the course. In addition to the formal course briefings, formal course reports are accomplished at the end of each semester and

include, as a minimum, results for all of the material presented during the course briefing, final grades, assessment information (tied to specific course objectives outlined in the syllabus and the course assessment plan), and any lessons learned during the semester. There is also a formal class-observation program in which faculty members attend each other's classes to observe instruction techniques and teaching style. In this program, each instructor is expected to observe at least two other instructors each semester. These sessions are formally noted on a bulletin-board tracking system, ensuring 100% member participation.

The program also has a standing curriculum committee that reviews all proposed changes to individual courses, the Computer Engineering program at-large, and any other impact to the Computer Engineering curriculum. Their purpose is to control changes to the curriculum through a formal review and approval process. This committee also works together with the Academy-wide curriculum committee to determine how changes to courses administered by other departments may affect our major's curriculum (prerequisites, course content, etc). Finally, the Advisor-in-Charge of the Computer Engineering program is also the program's liaison to the math department, ensuring any proposed changes to the math curriculum are well understood by the Computer Engineering program's curriculum committee.

Each year both the Department of Electrical Engineering and the Department of Computer Science have full-day, "offsite" meetings prior to the beginning of the Fall semester. These meetings are used to review and update the faculty on department administration, changes to curriculum and academics, the assessment process, and professional development. They also serve as an opportunity to build enthusiasm among faculty for the upcoming school year.

To ensure the assessment process is well-organized and properly executed, a combined team of members from the Department of Electrical Engineering and the Department of Computer Science form the Process Improvement Principals (PIPs) to evaluate all aspects of the Electrical Engineering and Computer Engineering programs on a regular basis. This group typically meets twice per month, and discusses items such as quality of instruction, program assessment, instructor professional development, and course development. This group's membership is diverse, including members with significant teaching experience (8+ years), instructors recently returned from operational Air Force assignments, certified professional engineers, and senior department personnel. The outcomes of the group's discussion often include recommended changes to course content, assessment activities, etc.

In summary, the Computer Engineering faculty has the qualifications, motivation, and leadership to support, assess, and evaluate and develop the Computer Engineering program. The program's annual assessment process involves all faculty and support personnel to ensure the program is adequate, and that the program's supporting goals and objectives are met.

6. Facilities

Classrooms, laboratories, and associated equipment must be adequate to accomplish the program objectives and provide an atmosphere conducive to learning. Appropriate facilities must be available to foster faculty-cadet interaction and to create a climate that encourages professional development and professional activities. Programs must provide opportunities for cadets to learn the use of modern engineering tools. Computing and information infrastructures must be in place to support the scholarly activities of the cadets and faculty and the educational objectives of the institution.

Facilities and other resources are required to deliver the curriculum and support the program's goals, outcomes, and objectives. The achievement of both Departments' goal to "Acquire and maintain required budget, facilities, and equipment to meet our mission" is measured through the attainment of the following objectives:

- Each course director will
  - Provide an annual forecast of course resource requirements.
- Each division chief will
  - Maintain a short-term (annual) and long-term (seven-year) resource requirements plan for his or her assigned division's curriculum.
- The Departments will
  - Vigorously strive to obtain the required budget to meet our goals, outcomes, and objectives.
  - Maintain appropriately equipped, state-of-the-art laboratory facilities.
  - Maintain appropriate, state-of-the-art computational facilities for use by faculty, staff, and cadets.

Program facilities, which include classrooms, dedicated laboratories, combined classroom/laboratories, and the equipment residing therein, are sufficient to meet our program goals and objectives. Furnished with state-of-the-art equipment, supplies, computers and software, the cadets have all the necessary resources to meet the requirements of the various courses and successfully achieve the Program Curricular Outcomes.

6.1 Adequacy of Facilities

Individual attention to each cadet is one of the strengths of the USAF Academy educational program in general, and the Computer Engineering program in particular. The maximum allowable section size for any Computer Engineering course is 24 cadets, enforced by the size of the classrooms. We intentionally keep the cadet-to-instructor ratio small in the laboratory-intensive courses (El Engr 281, El Engr 321, El Engr 322, El Engr 382, El Engr 383, and all Comp Sci courses at the 200 level or above) so that faculty-cadet interaction can be effective. The maximum section size is determined by laboratory space, equipment inventory, and desired cadet-to-instructor ratio based on the course syllabus. When enrollment increases, additional sections are added to avoid large section sizes.

Table 10. Computer Engineering Classroom and Laboratory Facilities

Room No.	Purpose of Lab Classroom, Courses Taught	Condition of Lab	Adequacy for Instruction	Student Stations	Area (Sq Ft)
2-4A	Robotics Lab: El Engr 387, 464, Research	Excellent	Adequate		392
2D26	Image Processing, Optics, Digital Signal Processing: El Engr 434, 464, Research	Excellent	Good	3 Optic Tables 10 Lab Benches	1064
2E6	Electrical Circuits & Systems: El Engr 231	Excellent	Excellent	12	1008
2E35	Comm/Computer/Robotics: El Engr 434, 443, 444, 447, 448, 485, 387	Excellent	Excellent	10	1064
2E48/ A	Computer Engineering: El Engr 382, 383, Comp Engr 465, 466	Excellent	Excellent	38	1904
2-6D	Design Techniques & Project: Comp Engr 465, 466	Excellent	Excellent	7	318
2F2	Design Techniques & Project: Comp Engr 465, 466	Excellent	Excellent	5	224
2F4	Design Techniques & Project: Comp Engr 465, 466, El Engr 495	Excellent	Excellent	11	696
2F44	Introduction Digital Systems: El Engr 281, El Engr 382	Excellent	Excellent	24	924
2F50	Electrical Power Systems: Engr 311	Excellent	Excellent	18	924
2G2	Instrumentation—Design: Comp Engr 465, 466	Excellent	Excellent	8	532
2G6	Electronic—Design Project: El Engr 321, 322, 473, Comp Engr 465, 466	Excellent	Excellent	N/A	1120
2G8	Anechoic Chamber-Microwave: El Engr 443, El Engr 444, Research	Excellent	Excellent	6	952

Room No.	Purpose of Lab Classroom, Courses Taught	Condition of Lab	Adequacy for Instruction	Student Stations	Area (Sq Ft)
2G24	Electronic Circuits: El Engr 321, 322	Excellent	Excellent	16	1120
2G26	Electronic Circuits: El Engr 321, 322	Excellent	Excellent	13	880
2G28 A	VLSI Laboratory: El Engr 473, Research	Excellent	Excellent	1	210
4F3 4F5 4F7	Computer Programming: Comp Sci 201, 225, 380, 359	Excellent	Excellent	24 Each	616
4F9 4F25	Computer Systems: Comp Sci 483, 467	Excellent	Excellent	24 Each	616
4F11 4F13 4F17 4F19 4F21 4F23	Core Classes: Comp Sci 110	Excellent	Excellent	24 Each	616
2D7	Computer Programming Computer Systems All majors courses	Excellent	Excellent	24 Each	999
2D2 2D4 2D6	Core Labs: Comp Sci 110	Excellent	Excellent	24 Each	999

A summary of facilities utilized by the Computer Engineering program is outlined in Table 10. It details the condition, use, and size of all classrooms, dedicated laboratories, and combination classroom/laboratory rooms.

- Integrated classroom/laboratory rooms are used for all introductory courses (El Engr 231, 281, and Engr 311). Dedicated laboratory equipment at each station is available for use during lecture, integrated lecture/laboratory exercises, and for laboratory experiments. Combination classroom/laboratories are used for the computer systems courses as well (El Engr 382, 383).
- The classroom dedicated to the electrical power course has equipment stored in the classroom, but it is only set up for laboratories and integrated class exercises.
- Dedicated laboratories are used for research and courses in robotics, optics, signal processing, VLSI fabrication, instrumentation, electronics, and design techniques and projects (Comp Engr 465, 466).

The only current area of concern is the lab space shared between the Computer Engineering and Electrical Engineering senior design course (Comp Engr 465/466, El Engr 463/464). If the numbers of Computer Engineering majors continue to

increase, the need may arise for dedicated Comp Engr 465/466 bench space. In anticipation of this problem new laboratory areas are being installed in 2F2 and 2-6D. A redistribution or reconfiguration of our current laboratory space may still be required relieve the strain on course needs and senior design project space. This will be addressed during AY 2002-2003.

6.2 Adequacy of Equipment

As explained earlier in this document, the Computer Engineering program is supported by four administrative units called Divisions. Three of these divisions reside in the Department of Electrical Engineering, where the electronic laboratory facilities reside. They have a Department resource manager who is responsible for planning new purchases and replacement of obsolete equipment by consolidating inputs from across the department. A standard Air Force seven-year projection is used, updated continuously, and reviewed by the senior staff at least annually. This plan forms the basis for the department's input to the Academy's Budget (current year), Financial Plan (next year), and Program Objective Memorandum (following six years).

Program classrooms and laboratories have a wide range of electronic equipment, supplies and computer software available for cadet use. The list of available equipment and software is included as Appendix I-D. Courses involving labs are carefully scheduled to ensure each cadet has appropriate access to all equipment. As such, laboratory exercises and course design projects are almost always completed on an individual basis or by a team of two. For the capstone senior design project the work is partitioned so the facilities can accommodate a larger lab team.

Electronic equipment in the Electrical Engineering labs is maintained by four department technicians (three of whom work with cadets in the Computer Engineering program) and an on-site USAF Academy Precision Measurement Equipment Laboratory (PMEL). The PMEL calibrates all measurement equipment on a schedule determined by the type of equipment. Each department technician is responsible for the maintenance of the equipment in a particular division. Technicians working with Computer Engineering majors are:

- Electronic Systems Division:
  Mr. Richard Speakman (38 years experience, 14.5 years at USAFA)
- Computer Systems Division:
  Mr. Jon Trudeau (18 years experience, 14 years at USAFA)
- Core Technician:
  Ms. Susan Elmore (22 years experience, 9 years at USAFA)

The Computer Science Department maintains equipment for the fourth division of the Computer Engineering program, consisting mostly of computer systems and computer application programs. The Computer Science Department obtains funding

for computer equipment through Dean of Faculty (DF) funds. There is a four year replacement plan for equipment maintained in the Computer Science labs using these DF funds. Additional funds from the National Security Agency (NSA) are also used to replace equipment in our Information Warfare Laboratory. Mr William (Bill) McCrary is the technician responsible for maintaining hardware and software in the department's labs.

6.3 Modern Engineering Tools

Throughout our introductory to our advance courses, many modern engineering tools are used to give cadets experience and proficiency. Wherever possible, cadets use state-of-the-art computer systems and application programs. The Information Warfare Laboratory is available to cadets and includes Pentium III 450 MHz systems. Specialized software (under site license) is used in several advanced courses such as the AdaGIDE software development environment, the GNAT Ada compiler, the AdaGraph graphics package, the RAPID user-interface development tool, Visual Studio C++, the Java Developer's Kit, and the Rational Designer's Suite including Rational Rose and Rational Requisite Pro.

The Computer Engineering program makes extensive use of computer-aided engineering through the use of a variety of software packages. Every required program course, and nearly every eligible elective course, makes use of one or more programs for simulation, analysis, design, or testing of designs. Table 11 provides a detailed list of the software used in Computer Engineering courses, the courses that use them and the depth of cadet experience expected in the course. The most commonly used analog and digital circuit simulation program is PSpice, used in the required courses El Engr 231, 281, 332, 321, 322, and Comp Engr 465/466. Programming practice is achieved in all the Computer Science courses, along with:

- El Engr 332, where MATLAB programming is used extensively for analysis and design;
- El Engr 382, Microcomputer Programming, where cadets learn the fundamentals of programming in assembly language;
- El Engr 383, Microcomputer System Design I, where cadets learn the fundamentals of programming in 'C'; and
- Astro 320, Introduction to Astronautics for the Engineer and Scientist, where cadets gain another high-level language programming experience in MatLab.

Table 11. Engineering Tools and Expected Cadet Experience Level

Course	Tools	Exposure	Experience Level
Comp Sci 110/201/225	AdaGIDE, GNAT Ada Compiler, AdaGraph	Programming Exercises, Lecture	Excellent
El Engr 231	Function generators, oscilloscopes, multi-meters	Integrated lecture/lab/demo	Good
	Math software (cadets' choice: Matlab, Mathamatica)	Computer exercises and homework	Fair
	PSpice Capture (circuit simulation software)	Computer exercises and homework	Introductory
	DC Challenge	Homework	Introductory
El Engr 281	PSpice Capture (for digital applications)	Homework and Labs	Fair
El Engr 321/322	PSpice Capture	Homework and Labs	Excellent
	Function generators, oscilloscopes, multi-meters	Labs	Good
El Engr 332	Matlab	Homework	Good
El Engr 382	Programming the 68HC12A4 micro-controller	Lecture and 9 labs	Excellent
	CASM Compiler (C and Assembly Language)	Every lecture, all 9 labs	Excellent
El Engr 383	68HC12B32 microcontroller	5 labs and final project	Excellent
	HP 1664A logic analyzer	22 lessons	Fair
	ICC12 C Compiler	5 labs & final project	Excellent
	PALASM (PAL Compiler)	3 labs and final project	Excellent
	PALs, GALs, use of ALL-11 Universal Programmer	15 exercises	Good
Comp Engr 465/466	Circuit Board Fabrication	Lecture	Fair
	Soldering	Integrated lecture/demo	Fair
	PSpice Capture	Design project	Excellent
	MS Project (project management software)	Design project	Good
	Rational Rose Design Tool	Design project	Good

6.4 Lab Safety

Standard safety procedures are taught and enforced. Cadets are not allowed to wear jewelry in the lab, and a two-person policy for safety is the rule in all laboratories. Formal safety instruction is included in all introductory courses (El Engr 231, 281, and Engr 311) as well as the first lab intensive courses (El Engr 321 and 382). Several exercises in Engr 311 (Power Systems) involve potentially hazardous voltages. The cadets are briefed at the start of these exercises and their work is

constantly monitored by instructors and technicians. In all courses, cadets found violating prescribed safety procedures are dismissed from the lab.

The Dean of Faculty and all departments have assigned safety officers who are responsible for assuring conformance with accepted safety standards in all laboratory, classroom, and office areas. Inspections are routinely conducted by these safety officers at all levels. Any discrepancies are reported, and corrective action is taken within a specified time.

6.5 Computing and Information Infrastructure

6.5.1 Computer Facilities Available for Use in the Engineering Programs

The focus of the USAF Academy's academic computing is the USAFAnet local area network (LAN). USAFAnet connects a personal computer (PC) at each cadet's dormitory desk to other USAF Academy computer resources by a fiber optic LAN system. The cadets' personal computers are used whenever possible for course work. Certain courses require capabilities exceeding the personal computers and a full array of supermini and workstation computer resources are also available through the 10th Communications Squadron and the individual engineering departments.

In order to connect to the USAFAnet LAN, each cadet, starting with the class of 1990, have been required to purchase a personal computer upon entry into the USAF Academy. The cost of the personal computers issued to each cadet is deducted from the cadet's pay and it is the cadet's property upon leaving the Academy. The standardized configuration and software of the computers allows faculty to plan and administer courses with the assurance that each cadet has a known set of computer resources at his or her personal disposal. On-site warranty for parts is provided by the manufacturer and maintenance is through a third party maintenance contract. A five-year history of cadet computers is presented in Table 12.

The USAFAnet computer network provides services to each cadet's dormitory room using Windows NT Server 4.0 and Windows Server 2000 software. Wireless access points are being installed in the cadet library and throughout the Fairchild Hall academic buildings, and the Class of 2006 will be the first class to receive wireless network cards.

Network users have access to the Internet, electronic mail, bulletin boards, retrieval systems, laser printers, and disk drives for sharing or exchanging files. Gateways also connect USAFAnet to other colleges and universities, military and government installations, the Defense Data Network, and the Internet. Since its initial installation, USAFAnet has been expanded to all offices on the

Academy (over 8,000 users) providing connections reach all the faculty personal computer systems as well as laboratory, athletic, and administrative functions throughout the cadet area.

Table 12. Cadet Computer Purchase History

	Class of 2002	Class of 2003	Class of 2004	Class of 2005	Class of 2006
Make	Applied Computer Tech	Dell WS-210	Dell WS-220	Dell Latitude C600	IBM T-30
Type	Desktop	Desktop	Desktop	Laptop	Laptop
CPU	Pentium II	Pentium III	Pentium III	Pentium III	Pentium IV
Speed	350 MHz	450 MHz	733 MHz	850 MHz	1.4 GHz
RAM	64 MB	128 MB	128 MB	256 MB	256 MB
Hard Drive	6.5 GB	13 GB	20.4 GB	20.4 GB	40 GB
Other	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-TV card -ATI video card -CD ROM drive -DVD drive -Ethernet card	-ATI video card -DVD/CDRW combo - Ethernet card	-ATI video card -DVD/CDRW combo -Integrated Ethernet card

The Fiber Distributed Data Interface (FDDI) backbone of USAFAnet allows large amounts of data to be transmitted simultaneously, including digitized video and audio files. This fiber optic backbone provides throughput in the Gigabyte range. Controlled television signals can be viewed on the computer monitor at each cadet's dormitory desk. For juniors and seniors, these signals are sent to their computer's TV-card via Falcon Vision, a closed circuit TV network. For the classes using laptops (freshmen and sophomores), internet protocol video technology is used to view Falcon Vision. Programs using the video capabilities include additional academic instruction in a computer-controlled environment.

The USAFAnet or User Services systems include 80 Windows-based servers and two Unix-based servers. Maintenance of the network, the network interface devices, and the supporting computers are provided by the 10th Communications Squadron personnel as part of the Academy operating budget.

In conjunction with USAFAnet and the Academy-wide services provided by the 10th Communications Squadron, each engineering department maintains computer laboratories and software. The department computers support course administration and research by the faculty and directly support cadet laboratories and computer oriented courses. This support typically is in the form of data acquisition and analysis or design and simulation. A secondary use

of department computers is the administration associated with the operation of the departments. Over 250 of the 300 classrooms are equipped with over-head one-gun projectors for displaying high quality video images of computer output, VCR, or TV signals in the class.

The cost of computer use and maintenance for 10th Communications Squadron hardware is included in the overall operating budget of the USAF Academy. New hardware must be budgeted for eight years in the future and competes on an as-needed basis with other equipment purchased by the USAF Academy. Software for 10th Communications Squadron is purchased in an on-going manner, with money budgeted each year for improvements.

6.5.2 Services Available to Assist Cadets and Faculty

A standardized set of hardware and software is owned by the cadet and retained upon graduation. While the software has varied slightly over the past four years, it generally includes the following or equivalent products:

MS-Windows	MatLab	AutoCAD
MS-Office Pro	MathCAD	AdaGIDE
Adobe Acrobat	Mathematica	

There are several other software packages which may be installed on each computer under a site license. This software is intended to be used by the cadets for their course work. These software packages are to be removed from the computer upon the cadet's departure from the USAF Academy.

In addition to operating and managing the USAF Academy's computer systems, the 75 personnel of the 10th Communications Squadron Support Flight provide an extensive array of consulting and maintenance services to cadets, faculty, and staff. Walk-in, telephone, and e-mail support is provided to anyone requesting assistance with a personal computer or one of the other systems. Numerous courses are taught on pertinent software packages and their use in the Academy's USAFAnet environment. The 10th Communications Squadron Support Flight provides a single point of contact for the reporting of any computer-related maintenance problems. Both extensive in-house and contract maintenance are available on both a standing and as-required basis.

6.5.3. Accessibility of Computer Facilities and Services

All computer facilities linked to USAFAnet, including the cadet and faculty personal computers, are accessible 24 hours a day except during scheduled maintenance on the network. With each cadet owning a personal computer, the access by cadets to the USAF Academy's computing facilities is excellent. Other selected nodes, such as the Sun systems, are also accessible via telnet 24 hours a day.

Access to the 10th Communications Squadron facilities provided through USAFAnet is unlimited, with all cadets and faculty having an account. However, on selected nodes used heavily by academic classes, restricted account numbers for cadets enrolled in the class are issued by the 10th Communications Squadron after an instructor has requested an account for a class. For all academic classes, these accounts have unlimited time. All cadet accounts are monitored and logged by user account and time, but there is no billing for time to the cadet, class, or instructor.

7. Institutional Support and Financial Resources

Institutional support, financial resources, and constructive leadership must be adequate to assure the quality and continuity of the engineering program. Resources must be sufficient to attract, retain, and provide for the continued professional development of a well-qualified faculty. Resources also must be sufficient to acquire, maintain, and operate facilities and equipment appropriate for the engineering program. In addition, support personnel and institutional services must be adequate to meet program needs.

7.1 Adequacy of Institutional Support, Resources, and Constructive Leadership

As noted in its mission statement, the USAF Academy is dedicated to cadet education and continually ensures the resources required to accomplish this mission are available. The Department of Electrical Engineering works through the Engineering Division, and the Department of Computer Science through the Basic Sciences Division, to ensure we receive the necessary funds, facilities, and manning from the USAF Academy to accomplish the Computer Engineering program. Table I-5, *Support Expenditures*, in Appendix I-A describes the institution's support over the recent years.

As mentioned in the previous section of this report (detailing facilities), the departments administering the Computer Engineering program have a Supporting Goal to "*Acquire and maintain required budget, facilities, and equipment to meet our mission*". The attainment of this goal is assessed by evaluating the success of the following objectives:

- Each course director will
  - Provide an annual forecast of course resource requirements.
- Each division chief will
  - Maintain a short-term (annual) and long-term (seven-year) resource requirements plan for his or her assigned division's curriculum.
- The Department will
  - Vigorously strive to obtain the required budget to meet our goals and objectives.
  - Maintain appropriately equipped, cutting-edge laboratory facilities.
  - Maintain cutting-edge computational facilities for use by faculty, staff, and cadets.

This Supporting Goal, and its associated objectives, is restated here because their accomplishment is directly related to institutional support.

7.1.1 Institutional Support

Institutional support is excellent. Beyond a solid financial backing, the USAF Academy provides outstanding facilities, top-notch instructors, support personnel, and a commitment to academic excellence. The former resources will be addressed in the following paragraphs; the latter is addressed here. The USAF Academy is a unique institution in the fact that cadets are required not

only to excel in academics, but they must also allocate time for required military education and training, as well as mandatory athletics. All the mission elements (academic, military, and athletic) work closely together to ensure the cadets are allocated the academic time they need. This cooperation provides the departments of Electrical Engineering and Computer Science the opportunity to meet the Computer Engineering program's stated goals and outcomes.

7.1.2 Financial Resources

The United States Air Force Academy is a military service academy supported directly by the Department of the Air Force under the US Government's Department of Defense, with a high priority in funding. The Departments of Electrical Engineering and Computer Science operating expenditures (salaries, classroom, laboratory, and computing equipment, telephone and internet support, etc.) are provided through government funds. Research, grant, and gift funds supplement appropriated funds to support research work, cadet and faculty development and support (e.g., field trips, cadet participation in professional society conferences, etc).

In the Department of Electrical Engineering, the Director for Resources solicits inputs from Division Chiefs at the beginning of the calendar year regarding required funding for the coming year. Funding requirements for each course are provided by Course Directors and each electronics technician provides inputs regarding requirements to maintain and upgrade laboratories. Division chiefs consolidate this information to produce a detailed funding document which identifies required funding to meet course objectives and describe the impact on those objectives if full funding is not provided. These division requests are consolidated by the Director for Resources into a financial plan and forwarded to the Department Head for approval. Once approved, the financial plan is sent through the Engineering Division to the Dean of Faculty for funding.

In the department of Computer Science, computing resources are bought and maintained through two different channels. The computers for the core computing labs and for the faculty are purchased through the Dean of Faculty's budget managed by Mr. Bryant. Computing resources for the Information Warfare Lab and for the Modeling and Simulation Lab are purchased through research grants and sponsoring organizations.

To date, the funding used to support the Computer Engineering program has been more than adequate to ensure we meet our program objectives. We have been fully-funded in the past, and expect no changes in the foreseeable future.

7.1.3 Facilities and Equipment

The central academic facility at the USAF Academy, Fairchild Hall, is currently undergoing a complete renovation that includes both office and classroom

upgrades. When completed, the renovation will provide an even better academic environment, thereby improving the opportunity for attainment of program curricular outcomes.

In terms of equipment, the Dean of Faculty has a baseline budget of $864K/year for equipment that costs under $100K (capital equipment). To facilitate an equitable distribution of resources, each department completes an annual survey for new and replacement equipment. This survey specifies how often the equipment is used, the number of cadets who use it, whether or not it is used for research. The survey also includes safety information, and an impact statement if the equipment is not approved for purchase. In the case of replacement equipment, photos of current and recommended equipment are included. This information is submitted to the Dean of Faculty Equipment Allocation Board which objectively prioritizes all faculty requests for new and replacement equipment.

The Dean of Faculty's expendables budget (for consumables such as resistors, microprocessors, and other electronic and supply consumables) is $100K/year. Submissions for these supplies are standardized across departments and include a (sometimes) lengthy justification. This provides a completely defendable prioritization that is rarely disputed.

In the Department of Electrical Engineering, inputs from individual Course Directors and Division Chiefs allow the Director for Resources to maintain a consolidated list of expendable budget and capital equipment needs. The resource director has been able to obtain the required budget to meet program goals and objectives by providing the equipment, hardware, and software needed by faculty and cadets. In addition, the department typically receives the top three equipment items requested, and has never gone without a piece of equipment that is required to fulfill program objectives.

Computer requirements are handled separately, and funded at the institutional level. The USAF Academy has a five-year replacement cycle for office and laboratory desktop computers, three years for laptops. Each department at the USAF Academy has a person known as a Workgroup Manager who ensures these replacements take place.

7.1.4 Constructive Leadership

Leadership at the USAF Academy, as well as within the Department of Electrical Engineering and the Department of Computer Science, stems from a well-defined and proactive military chain of command that is common to all military organizations. The Superintendent, a three-star general who reports directly to the Chief of Staff of the Air Force in Washington, D.C., serves as the overall commander of the USAF Academy. The Superintendent receives input from numerous sources including the Dean of the Faculty, a one-star general who

reports directly to the Superintendent. The Dean of the Faculty, in turn, receives input from the department heads who report directly to him. The senior-ranking department head in each of the four academic divisions (Engineering, Basic Science, Humanities, and Social Science) serves as that division's chair. Colonel Cary Fisher, the Head of the Department of Engineering Mechanics, acts as the Chair of the Engineering Division (comprised of five departments). Colonel Hans Mueh, the Head of the Department of Chemistry, serves as the Chair of the Basic Sciences Division. The USAF Academy Engineering Division Chair position is the equivalent to a "Dean of the College of Engineering" at a civilian institution.

This leadership model contributes to achieving program objectives in many ways, including its active solicitation of feedback. For example, the Dean's annual Organizational Climate Survey serves as the cornerstone of a closed-loop assessment of faculty and staff (based on their perceptions and opinions). In addition, department-level leadership tools include annual (formal) course reviews, course critiques, regularly scheduled staff and department meetings, and annual off-site meetings for training and professional development.

7.2 Resources for a Well-qualified Faculty

The Dean of the Faculty uses a manning algorithm to allocate faculty positions to departments based on enrollment in the courses for which they are responsible. This algorithm determines the number of faculty positions available in each department.

As mentioned earlier in this report, the Computer Engineering program has developed a Supporting Goal to *"Recruit, develop, and enrich faculty and staff of the highest caliber*" which led to the set of faculty-centered objectives listed below:

- Each faculty member will be encouraged to
  - Perform a balanced, manageable workload in an excellent manner.
  - Maintain technical and educational competence.
  - Attend at least one symposium/conference per year.
  - Actively pursue academic promotion.
  - Belong to and participate in at least one appropriate professional society.
- Department leadership will
  - Be aware of and support appropriate faculty and staff aspirations and goals.
  - Provide continuing professional development and research opportunities for faculty and staff.
  - Strive to continuously improve the organizational climate.
  - Maintain a long-range recruitment plan.

Each of these objectives is discussed in the following subsections. In addition, an area of concern related to our faculty manning is discussed.

7.2.1 Resources to Attract Faculty

Historically, the Departments of Electrical Engineering and Computer Science have never had a problem attracting well-qualified faculty. However, they still actively recruit the best the Air Force has to offer. Unique to military faculty recruiting is a posting on the Air Force Personnel Center's (AFPC) website, while military and civilian faculty recruiting is done via postings on the departments' internet websites and advertisements in magazines. Many applicants have cited the departments' internet sites as their original source of information, so the departments' "WebMasters" make sure to keep the sites updated.

In the Department of Electrical Engineering, the faculty member serving as the Director for Personnel maintains a spreadsheet showing projected openings matched to incoming faculty. This spreadsheet is reviewed at least once a semester by the department's Deputy for Operations, Deputy Department Head, and Department Head. The Director of Personnel also maintains a list of interested and qualified personnel, and contacts them when an opening is available. If this list is in danger of being depleted, the Air Force Personnel Center will provide the Director of Personnel a list of all active-duty officers with advanced degrees in electrical and computer engineering. The Director for Personnel then contacts viable candidates to enlarge the list. The Deputy Department Head maintains a list of interested civilians and is in charge of advertising civilian openings, and chairing the selection committee. A similar process takes place in the Department of Computer Science to manage that department's manning situation.

7.2.2 Actions to Retain Faculty

Active-duty military faculty members (all are officers) are initially assigned to the USAF Academy for (at least) a three-year period in a controlled tour. (The term 'controlled tour' indicates the member will not be transferred to a different assignment during that period of time.) Some of those officers are later selected for a USAF Academy-sponsored PhD program, after which they return for another (minimum) four-year controlled tour. In addition, a limited number of military faculty are also offered a sequential tour (meaning they may stay another four years) after their current tour has ended. Civilian faculty members are hired on a renewable contract, with a contract period of three to five years.

Retaining faculty is rarely a problem. Nevertheless, program leadership makes every effort to ensure faculty members are content in their assignment. They solicit inputs at least once a year to determine how to best meet their faculty's needs. Also, faculty members have significant input into the process that determines what courses they teach, what their additional duties will be, and their professional development opportunities.

In the Department of Electrical Engineering, a balanced workload is assigned by the Deputy for Operations based on inputs from the Division Chiefs. The success of that balance is assessed from cadet critique results, and feedback from Division Chiefs. The department standard is an average of at least 4.0 (slightly agree) on cadet critiques for instructors and course evaluations. The department has a senior faculty member, serving in the role of a Trusted Agent, who reviews critique results on individual faculty members and courses. The Trusted Agent and Department Head work together with instructors who do not meet the desired minimum level to improve their instruction. In addition, the Trusted Agent and Division Chiefs meet with Course Directors whose courses fall below the desired 4.0 average to develop "get well" plans for their courses.

In the Department of Computer Science a balanced workload is assigned by the Department Head based on inputs from each faculty member. The department maintains an additional-duty interest survey that faculty members complete and then update each semester. The department also maintains a course directing and teaching interest survey that faculty members complete and update each semester as well. With these two inputs from faculty members, the Deputy for Curriculum and the Deputy Department Head make recommendations to the Department Head on which faculty member will course direct which course and what additional duties they will have during any particular semester. Each course and additional duty is assigned a work unit weight and each faculty member is compared to the other faculty members to ensure the workload is being balanced between members of the Computer Science department.

Academic promotions are highly encouraged and during the last six years, the program had ten instructors seek and obtain the next higher academic level. Currently, 94% of the Electrical Engineering faculty (16 of 17) belong to at least one professional society and have at least some active participation throughout the year. In the Department of Computer Science, 70% of the faculty (14 of 20) belong to at least one professional society and have at least some active participation throughout the year.

Faculty-wide, the Dean of Faculty's Organizational Climate Survey is administered and reviewed every year. Results in each category are deemed adequate if the department averages at least 4.0 (Slightly Agree) on faculty responses. At the annual department offsite the Department Head presents numerical results and trends from this survey to the faculty, and specifically addresses all written comments. If a concern is identified that can be addressed within the department, the Department Head will present a plan to resolve that issue.

7.2.3 Actions to Promote Faculty Professional Development

With the mission of the USAF Academy focused on excellence in the field of undergraduate education, the institution provides significant resources to

encourage excellence in the classroom. The Academy has a Center for Educational Excellence, which presents a comprehensive series of seminars on topics such as learning styles, teaching techniques, how to write examinations, active learning, use of technology in the classroom, etc. All faculty members are encouraged to attend these on-site lunchtime seminars, with new faculty required to attend a minimum number. In addition, funds are programmed into each department's annual travel budget to support at least one professional development activity such as a short course, conference, or workshop per year for every member of the Department. This includes military and civilian faculty, electronics technicians, and administrative support personnel. In the Department of Electrical Engineering, each instructor is required to attend lunch-time presentations by fellow faculty members that are related to education or research. Department support personnel are also invited to attend.

For faculty development purposes the Department of Electrical Engineering has implemented a formal Faculty Observation Program. The idea behind this program is to have every faculty member observe the performance of at least two of their peers in a classroom or laboratory setting. For evaluation purposes, Division Chiefs are required to observe each faculty member in their division at least once per semester. The information gathered helps the Division Chief as they perform, at a minimum, an annual feedback session to review the member's goals. For the rest of the faculty, the goal is to expose them to teaching techniques used by their colleagues. The implementation of this program is constantly evolving in an attempt to get maximum participation, and shows an increase every year. The Department of Computer Science has a similar observation program, although it is not as formal.

Faculty members are also encouraged to participate in professional society conferences, technical committees, and to hold leadership positions. Department members are currently involved in multiple technical committees and both regional and national leadership positions.

The Air Force Academy also provides some unique professional development opportunities not available at most universities. Faculty members are encouraged to serve as academic advisors to cadet squadrons, as professional ethics advisors, and as representatives to intercollegiate or club sports teams. In addition, during the summer, faculty members are encouraged to fill leadership positions in the cadet military training activities.

7.2.4 Current Area of Concern Related to Program Faculty

A current area of concern in the Department of Electrical Engineering is the non-availability of military officer-engineers in the coming years. Currently the Air Force is over 800 engineers short of operational requirements. The present approach to managing this expected shortfall is to reduce, through attrition, the Department of Electrical Engineering from its current 17 faculty members to as

few as 13 over the next several years. The department's current active duty USAF officer-engineers, once reassigned to other Air Force engineering positions, will not be replaced.

The Department of Computer Science is also concerned about the non-availability of military officer-scientists in the coming years. Well qualified officers are often directed into operational Air Force jobs rather than teaching positions at the Academy. Officers that are selected to be sponsored by the Academy for a PhD often must take an intermediate tour in the operational Air Force before returning to the Academy. This causes planning challenges for filling PhD positions in the Department of Computer Science. Officers that request sequential tours at the Academy are also directed into operational Air Force positions with a follow-on assignment back to the Academy. One approach for dealing with these challenges is to hire more civilian faculty members. During the past year the Department of Computer Science has hired two new civilian faculty members. One position is a permanent civilian position on our faculty and the other is for a three year contract that may be renewed.

The program leadership realizes that having fewer officers on the faculty is undesirable. While filling faculty billets with civilian faculty is possible, and funding has been made available to support this, both the Department of Electrical Engineering and the Department of Computer Science want to maintain a predominantly military officer-engineering faculty. This enables the faculty to also serve as military role models and military career counselors.

7.3 Adequacy of Support Personnel and Institutional Services

7.3.1 Support Personnel

Support personnel at the USAF Academy that directly impact the Computer Engineering program's mission include the Department of Electrical Engineering's electronics technicians, the Department of Computer Science's technician, and technicians working in Training Devices and the Engineering Division laboratory (formerly known as the Engineering 410 lab). All these technicians are highly trained individuals with a very strong work ethic. In fact, they are hired using stringent requirements that include excellent communication skills. They are skilled at working with cadets to turn vague concepts into a working system, and are invaluable members of the institution. As previously stated, everyone involved in the program is encouraged to attend professional development activities, with the technicians being no exception. They attend workshops and seminars throughout the year to either increase their knowledge in their field of expertise.

For the most part, these technicians instruct cadets on the proper use of test equipment and machinery so that cadets are able to complete class projects (often

a senior design project). The technicians are also well versed in the selection and purchase of parts that are used in these projects, and thus able to offer the cadets suggestions. If a task requires more skill than the cadet possesses, the technicians will actually perform the required work for the cadet. They have always provided outstanding support to our cadets, staff and faculty.

7.3.2 Library

The Academy Library collection consists of over 1.5 million items used in the library or checked out from numerous collections. The computerized cataloging and reference system may be accessed by all instructors and cadets either throughout the library or via the local area network. These resources include full-text journals, librarian-selected web sites, and a host of other databases useful to university-level researchers and cadets in all academic disciplines. There are over 350 key science and engineering periodicals. Finally, a complete interlibrary loan and document delivery service exists for all faculty and cadets, making the library one of the best undergraduate research facilities available. There is also a Special Collections Branch which has some of the best collections of aviation items in the world.

7.3.3 Directorate of Education and the Center for Educational Excellence (CEE)

The Center for Educational Excellence (CEE) is a part of the Dean of Faculty's Education Division. The Center's vision is to help transform the USAF Academy's educational system into a cooperative, cadet-centered, active learning environment that values the development of the Dean of the Faculty's Educational Outcomes in each cadet. The Center's mission is to support the USAF Academy faculty in their efforts to enhance cadet learning by offering state-of-the-art services in faculty and curriculum development, educational technology, research, and assessment. CEE offers a host of services including the following:

- Faculty Orientation. A comprehensive 20-hour program for new and returning faculty.
- Faculty Development Workshops to strengthen instructors' teaching and professional skills through one-to-three hour sessions in various topic areas.
- *The USAFA Educator*. A quarterly newsletter with contributions from across the faculty.
- A centralized Library where faculty may check out books and articles.
- Faculty Interest Groups. A forum for discussions on topics of interest.
- Faculty/Cadet Multimedia Lab for faculty and cadets. Used to create effective classroom presentations.
- Network Classroom Laboratory. Available to the entire faculty.
- Individualized Teaching/Learning Consultations which afford faculty members the opportunity to get researched-based suggestions.

- Centralized Assessment Resources. Focal point for accreditation documentation for the institution and all accredited program. Also helps course directors and instructors develop plans and gather and analyze data on course and program effectiveness. Maintains a USAF Academy assessment catalog.
- Software Support. Computer software expertise to help faculty members find, evaluate, and implement off-the-shelf educational software solutions.

7.3.4 10th Communications Squadron

The 10th Communications Squadron is dedicated to providing cadets, faculty and support personnel with outstanding communications, information systems, and services for the education, training, and support mission of the Air Force Academy. Specifically, they provide and maintain the computing infrastructure of the Academy including telephone management, network control, database management, personal computer maintenance, as well as photograph, illustration, television and video support.

7.3.5 Training Devices

Training devices supports USAF Academy courses by fabricating (or teaching cadets how to fabricate) projects designed in the classroom. Fabrication techniques are not limited to simple wooden structures; these highly skilled technicians are well versed in all modern fabrication technologies and associated machinery. This organization provides an invaluable service to the faculty by showing cadets that design is just one problem to be solved in the development of a product. Cadets are exposed to the real-world problems associated with engineering.

8. Program Criteria

The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. The program must demonstrate that graduates have:

a) knowledge of probability and statistics, including applications appropriate to the program name and objectives
b) knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.
c) knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.

The Computer Engineering curriculum at the US Air Force Academy consists of two primary components, the core-courses and the major's courses. Core courses are the basis on which all majors are built, and form a foundation for the development of cadets as future Air Force officers. The major's curriculum combines a tightly-integrated set of courses that is designed to provide both breadth and depth in computer engineering. The major's courses provide a solid theoretical foundation in the principles of computer engineering, as well as practical application of those principles via laboratory experience.

For clarity of presentation, the Computer Engineering Program Curricular Outcomes (USAF Academy equivalent of ABET Educational Outcomes) are restated here. They are presented again to illustrate that there are no disconnects between the curriculum and its expected outcomes.

Computer Engineering Program Curricular Outcomes

Each Computer Engineering graduate shall demonstrate satisfactory:

1) Application of the fundamental concepts of computer engineering to solve engineering problems.
2) Laboratory techniques including procedures, recording, and analysis.
3) Design, fabrication, and test techniques.
4) Use of contemporary computer engineering analysis, design, and test tools.
5) Written and oral communication skills.
6) Knowledge of ethical and professional responsibilities.
7) Breadth and depth of knowledge and skills in computer engineering, computer science, electrical engineering, mathematics, and other disciplines necessary to effectively identify and solve the types of complex, multidisciplinary problems they will face as Air Force engineers.
8) Knowledge of the benefits and the skills needed to engage in life-long learning.
9) Ability to be effective multidisciplinary team members.
10) Skills to be an independent learner while knowing when to seek help.
11) Knowledge of the role of Air Force engineering officers in our global society.
12) Knowledge of contemporary social, political, military, and engineering issues.

Note to the Reader: The Computer Engineering program-of-study detailed below is the one applied to the Classes of 2001 and 2002. In the Fall of 2001 the Dean of Faculty Curriculum Committee approved changes to the sequence of computer science courses taken by Computer Engineering majors. Those changes are in effect for the Class of 2005 and beyond. Also, in the Spring of 2002 the Dean of Faculty Curriculum Committee revised the core program for the Class of 2006 and beyond. That change has also caused some minor alterations in the core courses for the transition years (Classes of 2003-2005). Months of careful work and planning went into ensuring that none of these changes would adversely affect ABET accreditation for any of the USAF Academy's engineering programs, including Computer Engineering. Detailed programs-of-study for Computer Engineering majors in any class will be available during the visit.

8.1 Program Breadth

Breadth is found in both core and major's course requirements. The core academic program at the USAF Academy is built around offerings from the four academic divisions (Engineering, Basic Sciences, Humanities, and Social Sciences), along with required courses in Military Strategic Studies. The core program for a Computer Engineering major in the Class of 2002 consists of the following courses:

Engineering Division
- Fundamentals of Mechanics (Engr Mech 120)
- Air Base Design Performance (Civ Engr 210)
- Electrical Circuits and Systems I (El Engr 231)
- Electrical Power Systems (Engr 311)
- Fundamentals of Aeronautics (Aero Engr 315)
- Intro to Astronautics (Astro 320)
- Engineering Systems Design (Engr 410)

Basic Science Division
- Intro to Biology w/Lab (Bio 215)
- Applications to Chemistry I (Chem 141)
- Applications to Chemistry II (Chem 142)
- Intro to Computer Science/Information Technology (Comp Sci 110)
- Calculus I (Math 141)
- Calculus II (Math 142)
- Probability and Statistics for Engineers and Scientists (Math 356)
- Physics I (Physics 110)
- Physics II (Physics 215)

Humanities Division
- Language and Expression (English 111)
- Masterpieces of Literature (English 211)
- Advanced Composition and Public Speaking (English 411)
- Two Semesters of Foreign Language (For Lang 131/132)
- Modern World History (History 101)
- Intro to Military History (History 202)
- Ethics (Philosophy 310)

Social Sciences Division
- Intro to Behavioral Science and Leadership (BS 200)
- Economic Principles (Econ 221)
- Law for Commanders (Law 310)
- Intro to Management (Mgt 210)
- Politics and American Government (Pol Sci 211)
- International Politics and US National Security (Pol Sci 312)

Military Strategic Studies
- Intro to Air Force Operations (AFO 110)
- Foundations of Military and Aerospace Power (MSS 310)
- Intro to Joint and Multinational Operations (MSS 411)

For the Computer Engineering major's courses, breadth can be seen by considering the division structure we use as a basis for program administration and assessment. Required major's courses fall under the purview of one of four divisions: Signals and Systems, Electronic Systems, Digital Systems, and Computer Science. Major topics covered by the Signals and Systems courses include circuit analysis, introduction to communication systems, and fundamentals of electrical power generation, transmission, and use. The Electronic Systems Division courses describe the operation and application of basic "active" electronic devices. Digital System Division courses cover combinational and sequential logic system design, microcontroller system hardware design, assembly-language and C programming of microcontrollers, and both basic and advanced computer architecture issues. Finally, the Computer Engineering Division provides instruction in fundamentals of Computer Science, programming, algorithm and data-structure design, operating system fundamentals, computer networks, and a comparison of programming languages. The culminating experience for the cadets, where this broad base of knowledge is brought together, comes in the capstone design courses, Comp Engr 465/466.

8.2 Program Depth

Depth in the Computer Engineering program is implemented via the carefully integrated course sequences offered by each division. These are shown below:

Signals and Systems:
El Engr 231 - Electrical Circuits and Systems I
El Engr 332 - Electrical Circuits and Systems II
Engr 311 - Electrical Power Systems

Digital Systems:
El Engr 281 - Introductory Digital Systems
El Engr 382 - Microcomputer Programming
El Engr 383 - Microcomputer System Design I
El Engr 485 – Computer Architecture

Electronic Systems:
El Engr 321 - Electronics I
El Engr 322 - Electronics II

Computer Science:
Comp Sci 110 – Introduction to Computer Science
Comp Sci 201 - Programming in Ada
Comp Sci 225 - Fundamentals of Computer Science
Comp Sci 359 - Programming Languages
Comp Sci 380 - Algorithms and Data Structures
Comp Sci 467 - Computer Networks
Comp Sci 483 - Operating Systems

Senior Design Project and Seminar:
Comp Engr 405 – Senior Seminar
Comp Engr 465 - Systems Analysis and Design I
Comp Engr 466 - Systems Analysis and Design II

The Computer Engineering program does not have dedicated laboratory courses. Instead, the lab experience is integrated into lecture courses. The following list details the courses that include hands-on laboratory procedures:

Comp Sci 110 – Introduction to Computing
Comp Sci 201 – Programming in Ada
Comp Sci 225 – Fundamentals of Computer Science
Comp Sci 359 – Programming Languages
Comp Sci 380 – Algorithms and Data Structures
Comp Sci 467 – Computer Networks and Communication
Comp Sci 483 – Operating Systems
El Engr 231 - Electrical Circuits and Systems I
El Engr 281 - Introductory Digital Systems
El Engr 311 - Electrical Power Systems
El Engr 321 - Electronics I
El Engr 322 - Electronics II
El Engr 382 - Microcomputer Programming

El Engr 383 - Microcomputer System Design I
Comp Engr 465 - Systems Analysis and Design I
Comp Engr 466 - Systems Analysis and Design II

Computer Engineering majors also have an opportunity to go into greater depth in their studies via the Computer Engineering option requirement in their program. This requirement is satisfied by taking any 400-level Electrical Engineering or Computer Science course not specified in the list of major's courses, or El Engr 387 (Robotics). The most popular options are Comp Sci 438, Computer Security and Information Warfare, El Engr 387, Intro to Robotic Systems, and El Engr 473, Intro to CMOS VLSI Circuit Design.

Computer Engineering majors are also encouraged to take Engr 402, Professional Engineering Development, which prepares them for the Fundamentals of Engineering exam.

Table 13 shows a suggested course sequence for Computer Engineering majors in the Class of 2002. It is thoughtfully designed to even out a cadet's workload as much as possible (given the constraint that all cadets must graduate in four years) by balancing major's and core courses, as well as technical and non-technical subjects. Adjustments have already been made to this recommended sequence for the Class of 2003 and beyond to account for the core and majors course changes explained earlier. These revised sequences will be available during the visit.

Table 13. Recommended Course Sequence, Class of 2002

	Freshman (4°)	Sophomore (3°)	Junior (2°)	Senior (1°)
Fall	*Chemistry 141* *English 111* *For Lang* *Math 141* *AFO 110* **Hours 16.5** *+ Phy Ed*	*English 211* *Pol Sci 211* *History 101* *Physics 215* ***El Engr 231*** Comp Sci 201 Comp Sci 225 **Hours: 19.5** *+ Phy Ed*	*Mgt 210* *Economics 221* *Math 356* Comp Sci 359 El Engr 321 El Engr 332 El Engr 382 **Hours : 21.0** *+ Phy Ed*	*Philosoph y 310* *Astro 320* *Law 310* *Aero Engr 315* Comp Engr 405 Comp Engr 465 Comp Engr Opt **Hours: 18.5** *+ Phy Ed*
Spring	*Chemistry 142* *Engr Mech 120* *For Lang* *Math 142* *Physics 110* ***Comp Sci 110*** **Hours: 18.0** *+ Phy Ed*	*History 202* *Biology 215* *Civ Engr 210* ***Engr 311*** Comp Sci 380 El Engr 281 Math 245 **Hours : 20.5** *+ Phy Ed*	*MSS 310* *Beh Sci 200* Comp Sci 483 El Engr 322 El Engr 383 Math 340 **Hours 19.5** *+ Phy Ed*	*Pol Sci 312* *Engr 410* *English 411* *MSS 411* Comp Engr 466 Comp Sci 467 El Engr 485 **Hours : 19.5** *+ Phy Ed*

8.3 Mathematics and Applications

The Computer Engineering program requires two mathematics courses (Math 245 and 340) beyond the core requirements (Math 141, 142, and 356) for a total of 16.5 semester hours of math. Nearly all of the program-specific mathematics topics are covered in these courses as the following table indicates:

Table 14. Program Specific Mathematics Topics

Topic	Covered In Math Course(s)	Used in El Engr and Comp Sci Course(s) Related to
Basic Calculus	Math 141 Math 142	Circuit and System Analysis (El Engr 231, El Engr 332)
Complex Numbers/ Variables	Math 141	Circuit and System Analysis (El Engr 231, El Engr 332) Electrical Power Systems Analysis (Engr 311)
Differential Equations	Math 245	Circuit and System Analysis (El Engr 332) Robotics (A Popular Option) (El Engr 387)
Discrete Mathematics	Math 340	Algorithms and Data Structures (Comp Sci 380)
Probability and Statistics	Math 356	Advanced Computer Architecture (El Engr 485)

9. General Advanced-Level Program

Not applicable. No advanced level program accreditation is sought

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