APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

Vol. 5 No. 1 March 1990

TABLE OF CONTENTS

EDITOR'S COMMENTS 2

LETTERS TO THE EDITOR 2

OFFICER'S REPORTS 3

President's Report 3

COMMITTEE REPORTS 6

Financial Committee 6

Elections Committee 9

Meetings Committee 9

Committee on Artificial Intelligence and Expert Systems 10

Publications Committee 10

Software Performance Standards Committee 11

Other Committee Reports 18

CAEME COLUMN - Magdy Iskander 18

EM MODELING NOTES - G. J. Burke 33

RENDEZVOUS WITH A COMPUTER SCIENTIST - Virginia Stover 36

PLOTTING SOFTWARE PACKAGES - Paul Elliot 44

ADVERTISEMENTS 45

ANNOUNCEMENT-A SPECIAL ACES PUBLICATION 45

EDITOR'S COMMENTS

We expect to publish three Newsletter issues per year (March, July, and November) instead of four. This is primarily a cost-cutting move as explained by Jim in the President's Report. I think it is a good idea also because it should result in more articles and committee reports in each Newsletter. Some committees could use the extra month between issues to show some activity, and ACES members will have more time to send in what they have to share about computational EM, code use, etc.

Mike Thorburn, our Advertising Editor for several years, has resigned due to the demands of the last six months of his Ph.D. program. Mike was also the 1989 ACES Symposium Program Committee Chairman where his efforts greatly benefited all those who attended. Thanks for all the help Mike and best of luck with the home stretch to your Ph.D.

Paul Elliot
Newsletter Editor

ACES NEWSLETTER COPY INFORMATION

Issue Copy	Deadline
March	January 25
July	May 25
November	September 25

Send copy to PO Box 2044, Smyrna, GA 30081-2044 in the following formats:
1. A hardcopy.
2. Camera ready hardcopy of any figures.
3. If possible also send text on a floppy disk. We can read MICROSOFT-WORD and ASCII files on both IBM and Apple disks. On IBM disks we can also read Wordperfect and Wordstar files. If not possible to send a disk, the hardcopy should be in Courier font only for scanning purposes.

AUTHORSHIP AND BERNE COPYRIGHT CONVENTION

The opinions, statements and facts contained in this Newsletter are solely the opinions of the authors and/or sources identified with each article. Articles with no author can be attributed to the editor. The United States recently became part of the Berne Copyright Convention. Under the Berne Convention, the copyright for an article in this newsletter is legally held by the author(s) of the article since no explicit copyright notice appears in the newsletter.

NEW ADDRESSES FOR JOURNAL AND NEWSLETTER

Dave Stein (ACES Editor-in-Chief and Journal Editor) and Paul Elliot (Newsletter Editor) both have new addresses.

David E. Stein, ACES Journal Editor
Westinghouse Electric Corp.
PO Box 169
Linthicum Heights, MD 21090, USA.

Paul Elliot, ACES Newsletter Editor
Georgia Tech Research Institute
PO Box 2044
Smyrna, GA 30081-2044, USA

NEWSLETTER EDITORS AND WRITERS NEEDED

The ACES Newsletter could use the following:

Aquisitions Editor - to locate articles for newsletter
Advertising Editor - to solicit and coordinate advertising
Writers - to write occasional articles

Any volunteers should contact Paul Elliot, Newsletter Editor at (404) 528-7163

OFFICER'S REPORTS

PRESIDENT'S REPORT

The results of our first elections by mail are in! The results are not too surprising since there was only one candidate per office. This election provided us with the opportunity to try out the ballot-by-mail procedure. Ballot-by-mail is important because it provides every member a chance to participate in the elections. In the past, only those who attended the Symposium could vote. Ballot-by-mail also saves valuable time for technical presentations at the Symposium.

Congratulations are in order for Stan Kubina, our next President, and Harold Sabbagh, our new Vice President. Congratulations and many thanks to Dick Adler, Secretary, and Jim Breakall, Treasurer, for agreeing to run and serve in their respective offices. Also congratulations to Ray Luebbers who is a new addition to ADCOM as a Member at Large. Our new officers will need the same strong support from the ranks that I have enjoyed during my tenure.

In the September Newsletter, I introduced two questionnaires. One solicited opinions about the proposed July 1992 joint meeting with the IEEE Antennas and Propagation Society in Chicago. The other solicited opinions about ACES support of the IEEE AP-S Committee for Computer Applications in Electromagnetic Education (CAEME). The response to these questionnaires has been very scant. There were 10 responses to the first and 12 to the second. Any conclusions drawn from such meager returns cannot be considered valid.

Regarding the possible joint meeting with IEEE AP-S in June 1992, I believe ACES is not yet mature enough to share in this venture. We need to grow larger and improve our financial status before we try joint meetings. I am wary that ACES may lose its identity in a joint meeting with a much larger organization. We seek to preserve the informal atmosphere of the ACES Conference and maintain our single session format, which we could not do in a joint meeting with IEEE AP-S. There are also complications involved in revenue sharing which would have to be resolved before we could commit to the joint meeting. After much debate in March 1989 during two marathon ADCOM sessions, it was concluded that ACES should continue to meet in Monterey in March.

Regarding our sponsorship of CAEME, the ADCOM voted at our July meeting to support this effort. Acting on ADCOM marching orders, I began negotiations. By invitation of Prof. Magdy Iskander, CAEME Director, and the IEEE AP-S, I attended the first meeting of the CAEME Policy Board on December 2 and 3, 1989. Attendees included:

Dr. David Chang,	IEEE AP-S Vice President
Dr. Edward Ernest,	NSF Program Director
Dr. Magdy Iskander,	CAEME Director
Dr. Barry Perlman,	IEEE MTT-S
Dr. Irene Peden,	President of IEEE AP-S
Dr. William Pedler,	Corporate Technical Director for Hughes Aircraft.
Dr. Craig Rushforth,	National Electrical Engineering Department Head Association (NEEDA)
Dr. Rudolf Stampfl,	Director Educational Services, IEEE Headquarters

The primary purpose of this meeting was to finalize and approve the CAEME Bylaws and establish the 1990 Budget. I was asked to participate as a non-voting guest and represent ACES. I was given every opportunity to comment on wording and conditions of the Bylaws as well as Budget and other CAEME activities.

Approval of the CAEME Bylaws established a fee schedule for IEEE and non-IEEE professional societies. As a supporting professional society with a membership less than 3000, we can maintain full

voting status on the Policy Board by payment of an annual fee of $3000. I took this opportunity to formally request membership for ACES and pay the first installment as authorized by ACES ADCOM. We will also provide space for CAEME announcements in the ACES Newsletter. Privileges for participation in CAEME include access to CAEME reports and CAEME developed hardware. Other commitments and privileges will be described at a later time.

CAEME is currently being set up under a National Science Foundation (NSF) grant to aid educators within the U.S. The NSF grant for CAEME will most likely fund projects within the U.S., an appropriate use of U.S. tax dollars. However, I believe CAEME should consider foreign participation using non-government contributions such as from ACES and corporate sponsors. I understand this issue will be considered by the CAEME Policy Board in a future meeting. Contributions to CAEME are being solicited from Universities, Professional Societies, government sources, and private industry. Details on eligibility for participation in CAEME as a contributor or researcher can be obtained from Dr. Magdy Iskander, University of Utah, College of Engineering, 3280 Merrill Engineering Building, Salt Lake City, Utah, 84112 (801) 581-6944.

In keeping with the stature of the other Policy Board members, I suggest our representative should be the ACES President. However, with Stan Kubina's concurrence, I will serve for the first year and then Stan will step in. The NSF grant stipulates that the Chairman will be the IEEE AP-S President. When the grant runs out in three years, our representative may be eligible to be the chairman of the Policy Board.

Part of the role of ACES in CAEME is to provide nominations for the CAEME Technical Advisory Committee. This Committee evaluates CAEME products and recommends projects and focus of emphasis to the CAEME Policy Board. By invitation of Dr. Irene Peden, the 1989 IEEE AP-S President, it is my pleasure to nominate Dr. Edmund Miller to serve on this Committee as the ACES representative.

The ACES budget remains one of the critical areas that will need constant attention. We have been running for over 4 years without a budget or fiscal planning. Dick Adler has done a remarkable job in keeping expenses down, but ACES has now grown enough in size and activities to make it impossible to continue without some careful planning.

During my tenure as President, I directed Treasurer Jim Breakall to consolidate all ACES accounts and to set up an improved bookkeeping system. I authorized the purchase of a computer and software for this purpose. Using his spare time, Jim learned to run the software and brought the books up to date. Then last year, ADCOM attempted to establish a 5 year budget for ACES. It was difficult to determine the true expenses because complete records of the Navy subsidy were not kept. As better information becomes available, the budget must be updated. Our first attempt to establish a budget led us to raise the dues from $25 to $35, starting on January 1, 1990. But this increase will not be enough in the long run.

More recently, we have incurred unanticipated increases in expenses. Starting in December 1989, ACES had to pay its own postage. Previously, the Navy had provided free postage. In order to balance our budget we need to increase our dues again in 1991. In fact, unless we can find new sources of income, we will have to continue to raise the dues each year for the next three years.

To improve our financial status for calendar year 1990, we can no longer include membership dues as part of the Conference fees. The Conference fee will be $180 this year. The membership dues will be an additional $35. I would like to continue our policy of paying dues as part of the conference fee, but this is no longer a viable option for ACES.

Let me remind you that the ACES Conference does not have parallel sessions. You can hear every talk presented. There are no conflicts with other sessions. There are no hard decisions about which papers or which sessions you will skip. For these reasons, the $180 conference fee is still a good deal.

I have taken three more cost savings measures with the concurrence of Stan Kubina. First, I have directed that special issues of the Journal will no longer be published. Special topics will be covered by specially designated sections in a regular issue or by dedicating the entire regular issue to the special topic. Second, we will combine the two regular issues into a single Journal volume to be published approximately six months following the Conference Proceedings. And finally, we will reduce the number of Newsletters from four to three per year. The savings in printing and postage will allow us to balance our budget while we seek additional income sources. As our financial position improves, we will restore our publications as appropriate.

The budget process is complicated. We must foresee the future as well as provide for our commitments. It has become clear that we need a Financial Committee to develop budget projections and make policy recommendations to ADCOM. With the concurrence of Stan Kubina, I have established a Financial Committee composed of the current President and Vice President and the former President as voting members of the Committee, with the Secretary and Treasurer acting as non-voting consultants.

This Committee does not set policy, but makes policy recommendations to ADCOM. In reality, this Committee has been functioning for about a year but has had no official status. This Committee will function as an ad hoc committee until suitable amendments to our Bylaws can be made. A report to the membership from the Financial Committee appears elsewhere in this Newsletter.

My two years as your President have passed quickly for me. It has been challenging with some rewarding moments. I hope the efforts discussed above will help to smooth the transition for our new President.

James C. Logan

COMMITTEE REPORTS

FINANCIAL COMMITTEE REPORT

I would like to state the case for our increase in dues and other fees beginning in January 1, 1990. I would also like to present a budget plan for meeting our obligations and slowly increasing our reserves. This plan will be discussed and voted upon at the next ACES ADCOM in March. Interested ACES members are encouraged to attend this meeting which will be held on Monday evening, March 19, 1990, at 8:00 PM in 122 Ingersoll at the Naval Postgraduate School.

1. The first change in our dues since the inception of ACES was on January 1. Additional increases are anticipated over the next few years. We need to make some adjustments for inflation to support our activities and meet our responsibilities as a professional society.

2. The ACES Newsletter is now published separately from the ACES Journal. The Newsletter has four issues per year while the Journal has two. This is a step towards providing more timely information to the membership as well as improving the quality of the Journal. But, ACES must not lose money on printing and mailing. Our income which is primarily from membership dues must be sufficient to assure this outcome.

I propose we eliminate all special issues of the Journal. Regular issues will cover special issues by designation of special sections or dedication of the entire issue to a specialized topic. I further propose that we consolidate the two Journal issues into a single volume to be published six months after the Conference Proceedings. This will save printing and postage costs while providing essentially the same number and quality of papers. As soon as our financial pictures improves, we should restore the publication of two Journals.

In the case of the Newsletter, I suggest that 3 issues makes more sense for our organization. We hardly have enough activities at this stage in our development to justify a Newsletter every three months. A Newsletter every four months will adequately meet our needs.

3. We need to ensure that ACES has sufficient capital held in reserve to survive emergencies and lean times. Based on the experience of other professional societies, ACES should plan to have at least three years income in reserves. We currently have less than one year of income in reserves. However, we should not try to increase the reserves too rapidly in order to keep membership dues as reasonable as possible.

The proposed budget provides a five year plan to reach a one year reserve level. This goal cannot be achieved without an increase in dues. Dues will gradually increase every year over the next 5 years. Conference fees are as high as practical, set at twice the Government per diem rate.

4. We need to be sure ACES can survive when Government subsidies end. ACES started off enjoying very high subsidies from the Lawrence Livermore Laboratory, the U.S. Navy and the U.S. Army. The subsidies were provided only to get things started with the understanding that ACES would eventually become self supporting. The Livermore subsidy virtually ended when ACES moved to Monterey. The Naval Post Graduate School at Monterey has provided the bulk of our support ever since. Army and Navy subsidies are soon to end, as they should. In fact Navy subsidy of postage ended on December 1. Dues must be adjusted in anticipation of further reduction in subsidies.

5. The income from the ACES Conference and software sales plus U.S. Government subsidies has allowed ACES to keep dues low. The bulk of our income is from U.S. sources which have partially subsidized overseas memberships. For instance, the cost for overseas postage is higher than U.S. postage. Also, U.S. banks charge a high fee for cashing foreign checks.

6. ADCOM has voted to endorse and contribute to the IEEE CAEME project in recognition of our professional responsibilities. This is a long term commitment which must be included in our financial planning and fee schedules. Currently, it amounts to an average contribution of $5.25 per member, which will of course decrease as our membership grows.

The following tables give the financial projections that form the basis of the proposed budget plan.

PROPOSED 5 YEAR BUDGET FOR ACES

PREPARED 1/20/90

ESTIMATED EXPENSES

CALENDER YEAR

EXPENSE ITEM	'89	'90	'91	'92	'93	'94
CONFERENCE	$28,500	$30,000	$32,000	$34,000	$36,000	$38,000
SOFTWARE HANDLING	$ 2,905	$2,500	$2,000	$1,500	$1,000	$500
OFFICE EQUIP/SUPPLIES	$ 6,967	$2,000	$2,000	$2,000	$2,000	$2,000
COPYING	$ 608	$500	$500	$500	$500	$500
SEC-GENERAL	$ 4,065	$5,000	$5,000	$5,000	$5,000	$5,000
POSTAGE/GENERAL	$ 1,450	$500	$500	$500	$500	$500
ADV/FLYERS	$ 1,681	$3,000	$3,000	$3,000	$3,000	$3,000
JN PRINTING	$ 7,820	$8,211	$4,106	$4,106	$4,106	$4,311
ISSUES [1,2]	2	2	1	1	1	1
POST/MAIL	$0	$1,741	$871	$871	$871	$871
SPECIAL ISSUE	$0	$0	$0	$0	$0	$0
POST/MAIL	$0	$0	$0	$0	$0	$0
NL PRINTING[2,3]	$ 4,134	$4,341	$4,341	$4,341	$4,341	$4,558
NO. OF ISSUES	3	3	3	3	3	3
POST/MAIL	$ 871	$2,680	$2,680	$2,680	$2,680	$2,680
SEC/NL/JN	$ 2,809	$3,600	$3,600	$3,600	$3,600	$3,600
NL/JN SUPPLIES	$ 2,197	$3,500	$3,500	$3,700	$3,900	$3,900
EDITOR	$ 2438	$2,000	$2,000	$2,000	$2,000	$2,000
SUBSCRIPTIONS	$ 700	$700	$725	$750	$776	$776
CAEME SUPPORT	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
MISC	$1,427	$1,500	$1,500	$1,500	$1,500	$1,500
TOTALS	$ 71,572	$74,773	$71,322	$73,047	$74,773	$76,695

[NUMBERS IN SQUARE BRACKETS REFER TO NOTES BELOW]

ESTIMATED NUMBER OF MEMBERS

CALENDAR YEAR

MEMBER STATUS	'89	'90	'91	'92	'93	'94
US	462	500	500	500	500	500
NON-US	111	120	120	120	120	120
CANADA	17	20	20	20	20	20
MEXICO	0	0	0	0	0	0
CENTRAL AM	0	0	0	0	0	0
EUROPE & S.AM	66	70	70	70	70	70
ASIA	28	30	30	30	30	30
TOTALS[4]	573	620	620	620	620	620

ESTIMATED INCOME

CALENDER YEAR

INCOME SOURCE	'89	'90	'91	'92	'93	'94
ADVERTISING	$200	$400	$400	$400	$400	$400
CONFERENCE [5]	$30,426	$36,000	$40,500	$40,500	$40,500	$40,500
AVE REG FEE [6]	$152	$180	$180	$180	$180	$180
EST ATTEND	200	200	225	225	225	225
MEMBER DUES	$16,605	$21,700	$27,900	$34,100	$40,300	$46,500
AVE MEMB RATE	$29	$35	$45	$55	$65	$75
MEMBERSHIP	573	620	620	620	620	620
JN/PROCEED SALES	$2,885	$1,000	$1,000	$1,000	$1,000	$1,000
SOFTWARE SALES	$6,090	$5,000	$4,000	$3,000	$2,000	$1,000
SHORT COURSES	$6,237	$2,000	$6,000	$7,500	$8,000	$8,000
SAVINGS(INT) [7]	$1,522	$1,337	$1,904	$2,762	$3,873	$5,148
MISC	$1,692	$1,000	$1,000	$1,000	$1,000	$1,000
TOTALS	$65,657	$68,420	$82,668	$90,204	$96,988	$102,188

ESTIMATED RESERVES

CALENDER YEAR

INCOME SOURCE	'89	'90	'91	'92	'93	'94
DOLLARS INTO SAVINGS	-$5,915	-$6,354	$11,346	$17,157	$22,215	$25,493
CUMULATIVE BALANCE	$33,096	$26,742	$38,088	$55,245	$77,461	$102,954
RESERVES IN % INCOME	50%	39%	46%	61%	80%	101%

ESTIMATED MEMBER COSTS & CONTRIBUTIONS

CALENDER YEAR

COS T or EXPENSE	'89	'90	'91	'92	'93	'94
AVE EXPENSE/ MEMBE	$125	$121	$115	$118	$121	$124
AVE INCOME /MEMBER	$115	$110	$133	$145	$156	$165
DEFICIT OR SURPLUS PER MEMBER (AVE.)	-$10	-$10	$18	$28	$36	$41

NOTES:

NOTE 1: PLANS ARE FOR 1 REGULAR JOURNAL ISSUE EVERY YEAR. SPECIAL TOPICS MAY OCCUR IN ANY ISSUE AND SPECIAL ISSUES WILL NO LONGER BE PUBLISHED.

NOTE 2: THE BASE IS ACTUAL 1989 EXPENSE ADJUSTED FOR 5% NOMINAL INFLATION.

NOTE 3: PLANS ARE TO PUBLISH THE NEWSLETTER EVERY 4 MONTHS.

NOTE 4: ASSUME FLAT MEMBERSHIP AT 1990 LEVEL.

NOTE 5: STARTING 1990, THE REGISTRATION FEE DOES NOT INCLUDE THE DUES.

NOTE 6: MAXIMUM REGISTRATION FEE SET BY 2 TIMES GOVERNMENT PER DIEM.

NOTE 7: INTEREST AND DIVIDENDS ARE RUNNING AT ABOUT 5% OF SAVINGS, ON THE AVERAGE.

Questions and comments may be directed to ADCOM at the Conference in March.

James C. Logan

ELECTIONS COMMITTEE

I received the ballots for elections of ACES officers for the term beginning March 20, 1990 from Dr. R.W. Adler on January 18, 1990. The ballots were cast by ACES members in good standing as certified by Dr. Adler on January 15.

Elections Committee members present during the opening and counting of the ballots were J. C. Logan, D. W. S. Tam and S. T. Li. Envelopes were separated from the ballots to preserve voter's identities.

A total of 223 ballots were cast. Five ballots were judged to be invalid due to a lack of the voter's signature on the outside envelope.

The following were elected:

PRESIDENT:	Stan Kubina
VICE PRESIDENT:	Harold Sabbagh
SECRETARY:	Richard W. Adler
TREASURER:	James K. Breakall
MEMBER AT LARGE:	Ray Luebbers

The election results were reported to ADCOM via our President on January 18, 1990.

Shing Ted Li, Chairman

MEETINGS COMMITTEE

In the previous report the possibility of a Fall 1990 short course here at Penn State was mentioned. Since that time a new development has taken place. Hal Sabbagh of ACES has also been involved for some time with a group called TEAM, which is an acronym for Testing Electromagnetics Applications Methods. This group is about 5 years old, and is involved with computational electromagnetics. Their initial applications were related to magnetics and fusion research, but lately they have become more general and evidently there is significant technical overlap with ACES.

One area of overlap is that TEAM is in process of developing a set of canonical test problems. Since ACES is also putting together a set of canonical test problems, a cooperative effort between TEAM and ACES seemed appropriate. Hal Sabbagh has also been involved with TEAM, and evidently has made considerable progress in organizing a joint ACES-TEAM workshop on canonical problems. Current plans are for a two - day workshop to be held in conjunction with The Fourth Biennial IEEE Conference on

Electromagnetic Field Computation in Toronto, October 22-24, 1990. Anyone interested in participating in this workshop should contact Hal Sabbagh directly at (812) 339-8273.

Raymond Luebbers
Chairman, Meetings Committee
Electrical Engineering Dept.
The Pennsylvania State University
University Park, PA 16802 (814) 865-2362

COMMITTEE on ARTIFICIAL INTELLIGENCE and EXPERT SYSTEMS (ad hoc)

The next step has been taken in investigating the use of AI techniques in EM design problems. Casto Tsatsoulis, Assistant Professor of Electrical and Computer Engineering at the Telecommunications and Information Sciences Laboratory at the University of Kansas has been studying the use of AI techniques in communication systems. He has offered to share their experience with us at our 1990 Symposium. The idea is to consider transfering that expertise to the EM field.

Also, we will have an informal round table meeting sometime during the Symposium. Look for the time and place announcement when you arrive. All are invited to share their needs, ideas and solutions. Virgina Stover, our "Rendezvous with a Computer Scientist" author, is planning to attend.

See you at the Symposium. Look for the guy with "Artificial" written all over his face. As the saying goes, it's better to have artificial intelligence than none at all.

Wayne Harader
Chairman, adhoc, AI and Expert System Committee

PUBLICATIONS COMMITTEE

The success of any technical journal depends on (among other things) its ability to attract quality papers as well as readers. By this measure, the *ACES Journal* is more successful than ever before. Interestingly, we have experienced far greater success in obtaining journal papers than in obtaining the informal modeling-experience write-ups envisioned by the ACES Founders. (For this reason, the original *ACES Newsletter* rapidly evolved into the present *ACES Journal*)! Still, we are not attracting quite as many papers as we would like.

It is important to note that authors consider many factors when they select a journal. In addition to scope, they consider circulation (number of subscribers), prestige, "turnaround time" (from initial submission to actual publication), and "nuisance factors" (such as page charges and copy preparation requirements). In the latter two areas, the *ACES Journal* is highly competitive; however, prestige and circulation are normally established over time. The efforts of the ACES publications team have proven successful in accelerating this process, though much work lies ahead. At the next ACES AdCom meeting, scheduled for March 19, 1990 at the Naval Postgraduate School (immediately prior to our annual symposium), I shall discuss these efforts at length as I report on the "State of the ACES Publications". (All ACES members are welcome to attend the AdCom meetings).

For now, let me simply point out that additional ACES activities and services, above and beyond our publications and our symposia, are necessary for two reasons. First, certain activities can give rise to *ACES Journal* papers as well as *ACES Newsletter* articles. Second, by offering additional activities and services, we can increase our membership (and the circulation of our two publications, which in turn will make them more attractive to authors). In recognition of this need, the publications team has started two new activities: code user groups and a canonical problems solution project. We hope that these projects, and similar projects under consideration, will eventually be administered by independent committees.

Herein may also lie the solution to our other long-standing problems, obtaining informal modeling-experience write-ups for publication in the *ACES Newsletter*. To date, the problem has existed because the incentives to submit such material has not been sufficient. (Many of us who publish regularly in journals have had relatively little to gain by publishing in newsletters. Furthermore, when computational electromagnetics practitioners do publish in newsletters, they often choose a code-specific newsletter, not a general-purpose publication such as the *ACES Newsletter).* To compound the problem, the ACES Modeling Short Note, which was intended as a "quick and easy" way to publish modeling experiences, has never proven popular. Nonetheless, we anticipate that modeling-experience write-ups in some form will be a natural "output" of the canonical problem solution project and the code user groups. Your support of these activities will help guarantee this.

David E. Stein
Editor-in-Chief

SOFTWARE PERFORMANCE STANDARDS COMMITTEE

E. K. Miller

As you may know, ACES and the IEEE Antennas and Propagation Society started coordinated committees, both in 1988 and both initially chaired by Ed Miller, on the general topic of EM Modeling Software Performance and Validation. For various reasons, the AP-S Committee has probably been the more active of the two, principally by conducting a workshop at the 1989 San Jose meeting, which incidentally had active participation by a number of ACES members (three of the working-group leaders are charter ACES members). The following report (also being published as the February 1990 version of PCs for AP) summarizes what transpired at that workshop, and describes plans for another to be held at the 1990 meeting of AP-S in Dallas. It is included here because of its expected interest to ACES members, and to attempt bringing together ACES and AP-S activities in this important area. It should be emphasized that attendance at an ACES meeting or AP-S workshop is not required for you to participate in and contribute to these activities. What is most important is that we begin to act on recommendations of the kind included below. If real progress is to be achieved in producing more accurate, reliable, and easily used modeling software, one clear requirement is that validation receive the appropriate priority.

The report which is included below was actually intended to be distributed to the '89 Workshop participants reasonably soon after the meeting. It is based on the written input provided to me, quite promptly after the workshop for which I thank them, by the leaders of the various working groups into which we had organized at the workshop. Unfortunately, and although I had also quite promptly collated the contributions sent to me by the leaders, I apparently neglected to complete the process and send out the report as promised. I say apparently, because I was absolutely convinced I had actually done this, but can find no record anywhere to bear this out. So, although this report could have been provided by the October or December 1989 Newsletter, it has been inadvertently delayed until now. Sorry about that! Part of the explanation for this omission might be found in Ross Stone's column in the October 89 Newsletter, in which he mentioned some recent job changes, including among them that I had joined Sandia Laboratory. I have actually joined Los Alamos National Laboratory, but I thank Ross for the thought, even though I was intending to maintain a low profile after this job change. But that might be one explanation for my confusion over the phantom report, as such things can get lost in the shuffle of events like changing employers.

At any rate, at the June workshop, attended by about 45 participants, we divided into the following five working groups, with the indicated leaders (their telephone numbers are included in case you are interested in participating in the 1990 workshop scheduled for Dallas):

POLICIES & PROCEDURES—Professor Leo B. Felsen, (516) 755-4263

WIRES— Mr. James C. Logan, (619) 553-3780

SURFACES & PENETRABLE BODIES - Professor Donald R. Wilton, (713) 749-1875 and Dr. Harold A. Sabbagh, (812) 339-8273

FDTD MODELS - Professor Allen Taflove, (312) 491-4127

DATABASE ISSUES - Ms. Janet McDonald, (602) 538-7639

The workshop began with a number of presentations which surveyed EM Modeling Software Validation from the perspective of government sponsors, code developers, and code users. This was followed by a number of representative validation exercises. We collectively then selected the above topic areas as reasonable ones for more detailed discussion among smaller working groups. The workshop concluded with the leaders summarizing their working-group discussions for all participants. We also were hopeful that some follow on activities would ensue to begin implementing some of the findings and recommendations that had been reached, one part of which would be the summary report which follows below. We also anticipated that a workshop would be held at the 1990 meeting, an event which we are planning and about which you will find some further information at the conclusion of this column. The basic motivation for the '89 workshop was to launch an AP-S initiative in the area of software validation which might lead to a special issue of the transactions, starting a data base, and other relevant activities.

The summary report follows below. It is essentially the verbatim input provided by the working-group leaders, with only some modest editing. I hope that it gives you some idea of the issues that were discussed and the kinds of things that we might hope to accomplish in the future.

POLICIES AND PROCEDURES - L. B. Felsen

The Policies and Procedures Working Group placed the following discussion items on the agenda:

I. Role of benchmarks in software validation.
II. Information that should be stated in numerical data submitted for publication.

The following action was taken:

Item I.

a. It was agreed that benchmarks play in important role in validation.
b. It was agreed that numerical implementation of analytically exact solutions (primarily separable solutions, or solutions derived from these by general mappings and transformations) can provide valuable benchmarks.
c. It was proposed to assemble a catalog of "interesting" analytical solutions.
d. It was proposed to define criteria that qualify a code as a benchmark.
e. It was agreed to coordinate action on items (c) and (d) with other Working Groups.

Item II.

a. It was agreed to establish criteria for supporting information that should accompany published numerical data in order to permit independent assessment of the expected quality of the results.
b. Such criteria, having been established by the Working Group, will be submitted to the full Committee.
c. If the full Committee concurs, after suitable modification, it was agreed that the recommendations should be submitted by the Committee Chairman to the AP-S AdCom for their consideration as a requirement on numerical contributions in manuscripts submitted to the transactions.

d. The following information items were proposed for consideration in connection with the criteria:
   1. Allowable tolerances for system applications.
   2. Desired observables and critical parameters that affect these observables.
   3. Sensitivity checks (sensitivity of output to quantities generating the data).
   4. Tests for stability.
   5. Tests against benchmarks.
   6. Robustness within a stated parameter range.
   7. Computing time and computer used.

WIRES - James C. Logan

The task of this working group is to define suitable test and evaluation problems for method-of-moments thin-wire codes. This does not however, preclude the use of these problems for evaluating other techniques. The experience of the members of the group is primarily with thin-wire method of moments so we will confine our deliberations to problems suitable for such codes. Nonetheless, since many thin-wire codes also have surface "patch" capabilities, we will also include problems suitable for both wire-grid and surface-patch solutions.

There is a need for a standard format for describing the problem as well as for reporting solutions. The format must call out the parameters to be compared, the units to be used, and the coordinate system. Designing a suitable format requires more time than was available, and is perhaps beyond the scope of the WIRES Sub-group. However, since ACES plans to issue a call for "Canonical Problems", the format may not be an issue.

Large quantities of data may be required for purposes of (1) providing solutions with statements of the canonical problems, (2) reporting solutions and (3) for comparing solutions submitted for various computer codes. For example, the solution may be a current or charge solution over a collection of wires or surfaces. The use of a relational data base structure using an industry standard query language such as SQL is recommended to streamline the process of sharing and reporting on problem data. Due to a lack of time, the issue of a standards will have to be a topic for another meeting.

It was agreed that for comparison, the set of parameters to be used will generally be observables because most comparisons must necessarily be made to measurements. The set of parameters will at least include the following:

a. Impedance and admittance vs. frequency.
b. Current and charge distribution.
c. Near fields — both E and H as a function of position and frequency for some nominal radiated power level.
d. Far fields — gain or radiation intensity (at a specified range and radiated power level) as a function of frequency. Preferably expressed in spherical coordinates for standard cuts.

Submitted solutions to problems must include the problem description (especially pointing out any differences from the standard problem), the discretization scheme, and a brief description of the computer code used (including suitable references). Submitted solutions should also (1) indicate whether the results are computed in single or double precision, (2) designate the computer used for the calculations (and including such attributes as clock speed and word length) and (3), if available, provide run times.

The test problems should start out with relatively fundamental (or simple) configurations and build towards the complicated. Five categories were identified for problem areas. Examples of suitable problems in each area are given where time has permitted:

1. FUNDAMENTAL or "CANONICAL" Problems - limited to wires in free space or over perfect ground. Examples include tests for:

   a. Convergence of dipole and monopole solutions.
   b. Short-segment limits.
   c. Radii limits.
   d. Wideband behavior (fundamental dipole response).
   e. Behavior of stepped-radii wires.
   f. Mutual coupling between dipoles.
   g. Proper behavior near multiple wire junctions.
   h. Behavior of circular and square loops.

These tests involve calculation of admittance and impedance as functions of frequency, wire length and radius, and segmentation. Fundamental tests should also be used to check on the accuracy of near-field and far-field computations using these "simple" antenna configurations.

A few examples of specific wire configurations suitable for these tests may be found in the following references:

J. Rockway and J. Logan , NOSC TD 938, "The New MININEC (Version 3): A Mini-Numerical Electromagnetic Code", Sept. 1986.

J. Rockway, et. al, "The MININEC System: Microcomputer Analysis of Wire Antennas", Artech House, Inc., 1988.

E. K. Miller, R. M. Bevensee, A. J. Poggio, R. W. Adams, F. J. Deadrick, and J. A. Landt, "An Evaluation of Computer Programs Using Integral Equations for the Electromagnetic Analysis of Thin-Wire Structures", Tech Report UCID 75566, Lawrence Livermore Laboratory (March 1974).

One particularly good source of reliable data from which to judge the accuracy of a solution for simple wire configuration is:

R. W. P. King, "Tables of Antenna Characteristics", IFI/Plenum Data Corporation.

Some very good data for accuracy tests on stepped wire radius problems can be found in:

A.W. Glisson and D.R. Wilton, "Numerical Procedures for Handling Stepped-Radius Wire Junctions", University of Mississippi Final Report, Contract N66001-E-0156, March 1974.

2. EXTENDED CANONICAL Problems - problems suitable for wires and patches. Simple configurations of structures in free space or over perfect earth. Examples include:

a. A monopole mounted on a circular or square ground plane of finite size. The antenna may be centered or located anywhere. Mounting on an edge should pose a particularly difficult challenge.

b. A single monopole mounted on a box sitting on an infinite ground plane. Various antenna locations, from top center to the corner should be considered.

c. A similar box but with two monopoles mounted on it.

d. A monopole mounted on a sphere or cylinder in free space.

e. Two boxes, side-by-side, on an infinite ground plane, but otherwise not connected. The boxes should be sized and spaced to ensure close coupling.

Known sources of reliable measurement data may be found in:

J.W. Rockway and P. M. Hansen, NELC TR 1872, "Calculated Near Fields of Navy HF Whip Antennas", April 24, 1973.

J.W. Rockway and J.C. Logan, NOSC TD 168, "Calculated Electric Near Fields of Navy Shipboard HF Antennas", March 16, 1978.

S. Bhattachara, S.A. Long, and D.R. Wilton, "The Input Impedance of a Monopole Antenna Mounted on a Cubical Conducting Box", IEEE Transactions on Antennas and Propagation, AP-35, No.7, July 1987.

A.D. Yaghjian, "An Overview of Near Field Antenna Measurements", IEEE Transactions on Antennas and Propagation, Vol. AP-34, No.1, January 1986.

3. REAL WORLD Problems - a set of problems involving real world configurations for which reliable measurements are available. Due to a lack of time, no specific examples were generated.

4, ANTENNAS OVER EARTH - these are simple configurations of wires above and below earth, including wires that penetrate the air-earth boundary. The consensus was that a list of suitable problems, with reference data taken from the open literature, could be compiled from the numerous real earth problems and solutions already presented in the open literature by G. J. Burke of Lawrence Livermore National Laboratory.

Another source of data is:

C. M. Butler, S. A. Douglass, R. J. Croni, T. E. Begley, "Experimental Investigation of a Monopole in a Lossy Medium", University of Mississippi Final Report on Contract N66001-81-C-5991, September 1981.

C. M. Butler, C. A. Harrison, and A. W. Glisson, "Analysis of Electromagnetic Properties of the Ground Stake Antenna (Interim Technical Report)", University of Mississippi Report on Contract N66001-82-C-0045, June 1983.

C. M. Butler and C. A. Harrison, "An Experimental Study of Cylindrical Antennas Radiating in or Near a Lossy Half Space (Final Technical Report — Volume 1)," University of Mississippi Final Report on Contract N66001-82-C-0045, June 1983.

C. M. Butler, K. A. Michalski, S. Fillipovic, "An Analysis of the Coax-fed Monopole in a General Medium (Final Technical Report — Volume 2)," University of Mississippi, Final Report on Contract N66001-82-C-0045, July 1983.

5. SCATTERING or "RCS" Problems - This would involve simple, classical shapes, such as single wires, fat cylinders, spheres, and boxes. Due to a a lack of time, no specific examples were generated.

SURFACES AND PENETRABLE BODIES - D. R. Wilton and H. A. Sabbagh

The committee members responded with great enthusiasm to the task laid before them, which was to identify a number of interesting problem areas, and then to agree to write canonical problems for several of these areas. The committee felt that 2D and 3D problems, at all frequencies, involving perfect conductors and penetrable bodies were fair game. It also felt that it was our responsibility, as developers of canonical problems, to force people to solve unpalatable problems. In this way would we thoroughly exercise models and codes.

Problems involving spheres, coated-spheres, two-dimensional plates (including lossy materials), edge-on incidence, cubes, 5-sided cavities (with or without thick walls), quasi-aircraft shapes (such as a hotdog with wings) were all considered important. The following is a list of ideas that were mentioned:

(a) Perfect conductors.
(b) Thin wings.
(c) Turning 2D-plates into a 3D-object.
(d) Measurements; do they exist? Where can we get them?
(e) Analytic solutions; when do they exist? Who has them?
(f) Repeat problems with isotropic coating on the metal.
(g) Repeat problems with anisotropic media, such as advance-composites.
(h) 3D-ellipsoids; return to (f).
(i) 3D-prolate spheroids; return to (f).
(j) Eventually get to HF-shapes (ellipsoids, elliptical cross-section cylinders, elliptical cross-section hotdog, NASA almond).
(k) Bodies with tapered coatings, isotropic dielectric.
(l) Body-of-revolution with ring slot, given feed (calculate radiation pattern).
(m) Wing, whose cross-section consists of nonconducting leading edge, and PEC trailing edge. Also a tapered edge.

FDTD - A. F. Taflove

This working group on finite-difference and finite-volume electromagnetic modeling software validation agreed on a number of specific 2D and 3D wave interaction geometries to be modeled. These geometries demonstrate a wide range of physical phenomena and have been (or will be) the subject of substantial alternative investigations that provide reliable comparative data.

PENETRATION Two cavity-type penetration geometries were defined by our working group. The first is the 2D slit circular cylinder studied by Rick Ziolkowski using a dual-series approach. We will use Rick's published data for the TE polarization case, and examine the monostatic RCS through at least the first three interval cavity resonances for the empty cylinder.

The second penetration geometry is the Livermore PLUTO modeled by Umashankar and Taflove in AP-S in Nov. 1987. There is a wealth of experimental data for coupling to wires located within this 3D cavity. Our group agreed to focus on the case of a single 30 cm-wire centered within PLUTO for the conditions of the 1987 paper.

RCS Three scattering geometries were defined by our working group. The first is the 2D PEC ogive with blade defined by Lou Mitschang's 2D MoM working group for the RCS consortium. There should be ample MoM data available from Lou for our validation study. (Note: The RCS consortium is an informal group, involving government, academic and industry representatives, which is focussing on defining and developing RCS results for various kinds of problems. It would be beneficial if our AP-S, the ACES, and this consortium could collaborate. More about that later. EKM)

The second scattering geometry is the 3D PEC triangular plate with 1/100-wavelength crack defined by my 3D MoM working group for the RCS consortium. Again, it is expected that ample comparative MoM data will be available for our use.

The third scattering geometry is again in three dimension, the two-sphere problem solved analytically by J. H. Bruning and Y. T. Lo in AP-S in May 1971. Our group hopes to conduct these validation studies between now and the end of this year.

DATABASE ISSUES - J. McDonald

The group considered the categories of standards, access, transmission media, what, where and how to store data, validation, maintenance and how to initiate database development.

Some of the categories were straightforward. The standards that the database should use are SQL (Standard Query Language), common header formats for each entry and the ability to generate the entry in ASCII format. Access to entries should be read-only except for whoever is responsible for maintaining the database. Initially transmission media can be handled on a case-by-case basis until some standardization/formalization of the database is achieved.

Other categories were more difficult to define. The group decided that initially solutions to canonical problems with standardized header and background information would be stored by the individual running the canonical problem. The database entries could evolve to solutions of specific problems that may even be classified and have restricted distribution; the issues of resources and responsibilities must be resolved before the database can progress beyond unclassified, nonspecific problems. Each solution entry should contain information about which computer code was used, what hardware the code was run on and any other data that would help define the computing environment. Eventually solutions should be stored in relation to the type of problem being solved, code used, and classification/distribution restrictions.

The categories of validation and maintenance, while very important, must be initiated for the end-goal database after the resources and responsibilities issues are resolved. Initially validation and maintenance of solutions will be the responsibility of the individual running the problem and storing the solution for distribution to interested colleagues. Eventually solution should be validated by an appointed group before inclusion in the database.

The last category the group discussed was how to initiate the database development. If the proposed standards are approved, then the common header format must be defined. This information could be used in requesting the names, addresses and phone numbers of anyone in the user community with appropriate solutions to canonical problems they were willing to share. A directory could then beorganized by problems and computer code, published and distributed. Periodic validation workshops should be called to review and discuss solutions and to archive solutions that are outdated or that don't prove correct for reference. Thus, a database of solutions could be started and the user community could watch it evolve and make decisions on how to progress from the experiences gained with canonical shape solutions.

This concludes the draft report generated from the 1989 workshop. A one-day follow-on workshop on "EM Modeling Software Validation: Benchmark Solutions" is being organized for the Dallas meeting by the EM Modeling Software Committee. This event has as its principal goal that of beginning a library of "benchmark solutions." This library is expected to include results obtained from computational, analytical, and experimental sources and to be useful for a variety of purposes including: 1) providing a data base for use in validating codes/techniques under development; 2) comparing various codes/techniques when applied to a set of generic or canonical problems; 3) cross validating numerical and experimental results; and 4) determining needed model improvements by identifying areas of disagreement between various approaches.

The workshop will feature general presentations and individual working-group discussions in the areas discussed above. If you are interested in attending the workshop or participating in any of the above specific areas, please feel free to contact any of the team leaders above, or the organizer, Edmund Miller, (505) 667-4316.

OTHER COMMITTEE REPORTS

Next issue (July 1990) we hope to include reports from the following committees:

Software Exchange
Constitution and Bylaws
Awards
Historical
European Committee

CAEME COLUMN

Magdy F. Iskander

WOW! CAEME is now an NSF/IEEE Center for Computer Applications in Electromagnetic Education. In three short months, CAEME is a national center funded by the Undergraduate Science, Engineering, and Mathematics Division of NSF and managed by the Executive Office of IEEE. Under this broad-based organizational arrangement, CAEME has, thus far, attracted participation by three societies including the AP-S (host society), MTT-S, and the Applied Computational Electromagnetics Society (ACES). Hewlett-Packard decided to sponsor CAEME, and Hughes Aircraft is seriously considering joining in. Hughes actually sent an observer to Salt Lake City to attend the first CAEME Policy Board meeting.

Efforts in the last couple of months were focused on setting up operating policies and procedures (bylaws) for the CAEME Center. We were also planning the special session on education and arranging the workshop on Computer Applications in Education, both to be held in conjunction with the AP-S symposium in Dallas. The preparation of the CAEME catalog of available software is progressing smoothly, and the first CAEME book is in the planning stage. All in all, hundreds of hours were spent by volunteers who worked hard to make CAEME a success, a big success and true winner for all of us.

To describe CAEME activities, let us start from where we left off in the last CAEME column published in the October issue of the then AP-S newsletter. The following events are listed in chronological order:

1. NSF Evaluation of the CAEME Proposal

Shortly after we received the NSF grant of $250,000 for CAEME development, NSF sent us copies of the reviewers' evaluations of the CAEME proposal. A copy of these evaluations is included in Appendix A. I thought it would be important to share this information with you to emphasize the timeliness and the well-thought-out structure of the CAEME project. All ratings were "**excellent**" because the work is badly needed, key players were involved, and the project objectives and procedures were well thought out. Congratulations to our society for a job well done. My wholehearted thanks to all of you who not only made this task possible, but also enjoyable. Bud Adams, Ed Miller, Irene Peden, Eric Herz, David Chang, and, of course, Ed Ernst deserve special thanks for their efforts.

2. Policies and Procedures for the CAEME Center

Before proceeding with CAEME's projects and activities, it was necessary to have the Center's operating policies and procedures in place. Among other things, it is very important to identify key CAEME officers, their responsibilities and term of office, CAEME products and their delivery schedule, and set policies regarding participation by IEEE and non-IEEE and sponsorship by companies. A group of individuals representing NSF, the Executive Office of IEEE, and the various participating societies and sponsoring companies met on December 2nd in Salt Lake City to set and approve CAEME policies and procedures. This meeting was attended by Dr. Edward W. Ernst, Program Director from NSF; Dr. Rudolf A. Stampfl, Director of Educational Activities in IEEE; Dr. Irene C. Peden, President of AP-S (the host society of the CAEME project); Dr. David Chang, Vice President of-AP-S; Dr. Craig Rushforth, representing

the National Electrical Engineering Department Head Association (NEEDHA); Dr. Barry Perlman, representing MTT-S; Mr. Jim Logan, representing ACES; Dr. William Pedler, representing Hughes Aircraft; and myself. Dr. Zvonko Fazarinc, who is the designated CAEME representative from Hewlett-Packard, was not able to attend because he was celebrating his 40th wedding anniversary the same weekend. We missed Dr. Fazarinc in this important meeting, and we would like to congratulate him wholeheartedly on his anniversary.

A report on the first CAEME Policy Board meeting was prepared. It included copies of the approved policies and procedures, CAEME organization structure and technical activities, and a list of various CAEME projects and their proposed budget and schedule.

Appendix B-1 shows CAEME's organizational chart, while Appendix B-2 shows its technical activities. A copy of the approved policies and procedures is given in Appendix B-3. It is important to note the availability of seed money to sponsor projects of interest to CAEME, and the operational procedure for applying for and obtaining these funds. It may also be of interest to note that the CAEME Center will operate and carry out its projects by establishing several sub-committees and task forces. Examples of these sub-committees include the standards, new projects, publication, finance, and evaluation sub-committees. We will need many volunteers to work and contribute to these sub-committees. If you want to get involved, just let me know and we will be delighted to match your interest with the responsibilities of one of these groups. CAEME success depends on our commitment to help in areas that fit best our ongoing teaching and research activities.

One more comment regarding the policies described in Appendix B-3. Some of us may have different ideas on how the Center should operate. I believe that we were able to reach a suitable compromise between providing sufficient flexibility to get the job done, and adequate avenues for participating societies and sponsoring companies to contribute and play active roles in the development of CAEME. The latter is important in making the Center attractive for industrial and society sponsorship and hence achieve one of our important objectives of making CAEME self supporting after the three-year NSF funding.

3. Technical Activities

CAEME technical activities include the development of the software catalog, sponsorship of special sessions and workshops in international symposia, and the publication of books that include diskettes of educational software. Let us discuss each of these items in more detail.

3.1 CAEME Catalog

The first CAEME product is a catalog of available software. I have, thus far, compiled a list of approximately 25 software packages covering various aspects of electromagnetics education. It is urgent that we complete this task and make the catalog available to educators in the very near future. If you have a software package or are aware of some that should be listed in the catalog, please let me know as soon as possible. You may call me just to make sure that we are aware of your work and that it has been appropriately included in the catalog. A sample page of the catalog is given in Appendix C for your reference. In sending information regarding your software, please make sure that you include all the required information as outlined in this sample page.

3.2. A Special Session and a Workshop in the 1990 APS Symposium in Dallas

In the 1989 CAEME workshop, there were 17 presentations in addition to demonstrations, and a panel discussion in our one-day workshop. Although it was successful, it was felt that more time should have been allocated for software demonstrations and training on new available educational packages. Therefore, it was decided that it would be beneficial to report new courses and innovative teaching approaches in a special session of the 1990 symposium, while devoting the 1990 workshop to software demonstrations and panel discussions. Only two or three presentations will be scheduled in the workshop. These presentations will cover issues of broad interest to computer application in electromagnetics education.

After consultation with some of you, I have made initial invitations to individuals who are involved in the development of new innovative software and/or experimental procedures for teaching electromagnetics. Openings are still available in the workshop and if you have an idea or suggestion, please let us know. As in last year's workshop, we will have a variety of hardware platforms for participants to demonstrate their software.

3.3 CAEME First Book

According to the terms of the CAEME proposal to NSF, we intend to publish three books of developed, tested, and approved software for EM education during the three years of NSF funding. We will invite developers of some of the software packages listed in the catalog to participate and demonstrate their packages in the workshop. We will also acquire copies of these packages and make them available to the publication subcommittee for evaluation. Some CAEME funds will be used to upgrade some selected packages, change the hardware platforms to PCs and Macintoshes, and help bring others to set standards. Upon completing the selection and finishing the upgrading and evaluation processes, authors of selected software packages will be asked to contribute chapters to these CAEME books.

I may just add that in at least one of the CAEME books, focus will be placed on two or three large and general-purpose computer programs that may be made available at a small fee for education. In other words, in addition to including small software packages that are available at different institutions, licenses to distribute a limited number of large and general¬purpose programs will be negotiated to make these tools available for education. I will truly appreciate your thoughts on this issue and suggestions of large and general-purpose packages that may be pursued.

4. Concluding Remarks

It was just eight months ago that we submitted the NSF proposal. In September we calibrated its successful funding. Shortly after, the honeymoon was over and we all recognized the immense responsibility and the incredible amount of work needed to achieve CAEME objectives. The project is very ambitious and will require dedication, cooperation, commitment, and many hours of hard work. On the other hand, it is a unique and exciting opportunity to boost electromagnetics education. Let us all join hands and pray that our mission may not only be possible but also highly successful and enjoyable.

APPENDIX A

NSF Evaluation of CAEME Proposal

Reviewer A

This proposal addresses a critical problem in electrical engineering education and electromagnetics education. The PI is correct in his concern that students are turned off by the relatively mathematical and abstract nature of electromagnetics. The use of computer_assisted instruction, as proposed, should be a valuable tool in reversing this trend through visualization and intuition. The IEEE AP Society has excellent credibility and its access to the National EE Department Heads Association should insure wide dissemination and adoption of the tools generated by the proposed effort. Some attention should be directed toward debugging the software generated by this effort.

RATING: **Excellent**

Reviewer B

Conflict of interest
Did not review/evaluate

Reviewer C

This is an excellent and timely proposal. I am so pleased to see someone address an area which is so significant to the whole of electrical engineering. Students, especially those in the high speed switching areas (digital related courses, microelectronics, devices) must become re-oriented to this field. I like it.

RATING: **Excellent**

Reviewer D

There is great merit in having an organization such as the IEEE Antennas and Propagation Society undertake a project described in the proposal to benefit all in electromagnetics education. The preparation of a book of software for solving electromagnetic problems, with contributions from various authors is an excellent goal. The PI has excellent credentials.

RATING: **Excellent**

Reviewer E

Much needed work, especially since E & M area does not attract enough students. Impact can be very broad. Since it will come from IEEE it will be better received. Real goals and specific objectives are somewhat obscured by a rambling discussion.

RATING: **Excellent**

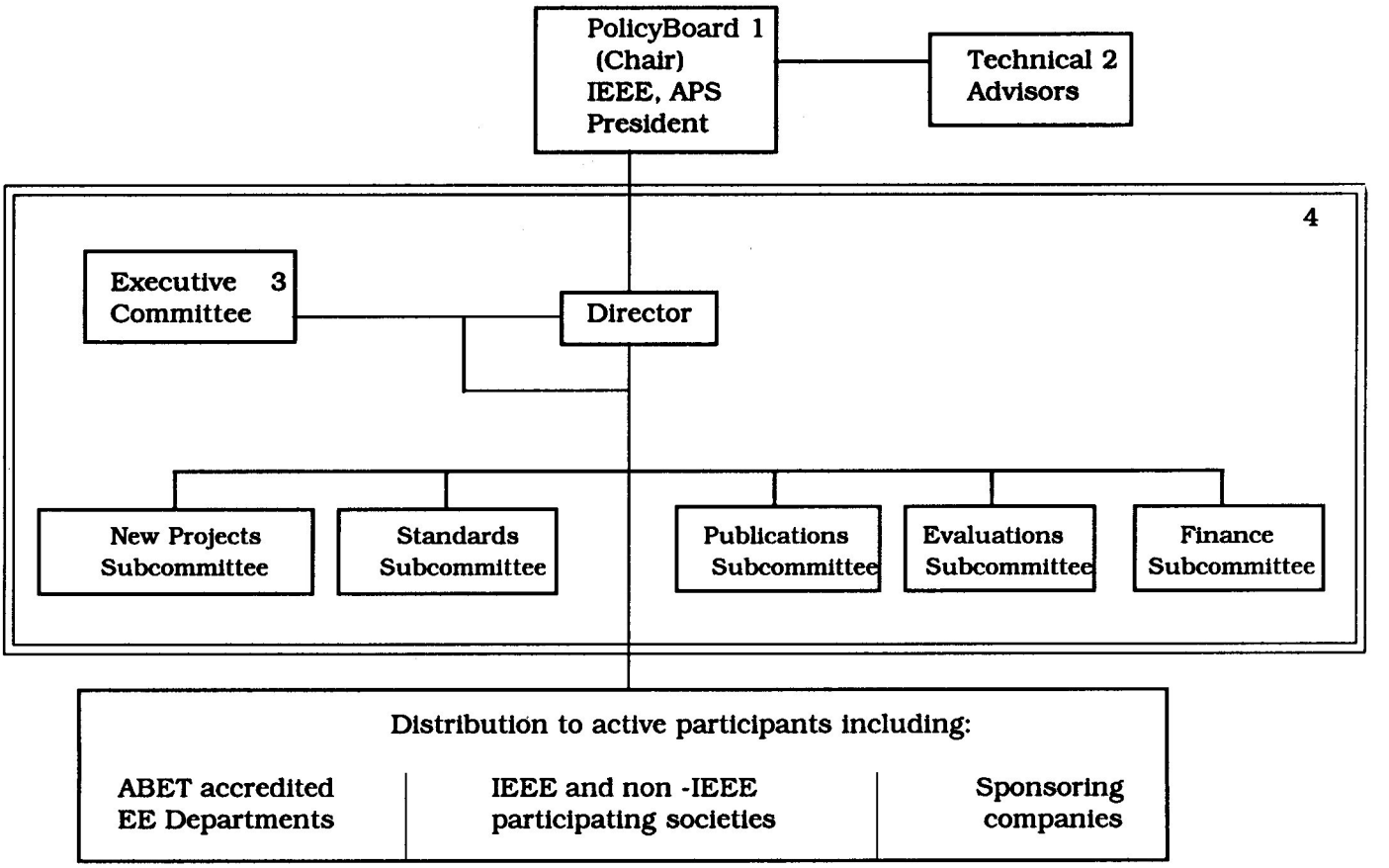
Reviewer F

- Addresses a major need
- Can have a major impact
- Excellent dissemination plan. Provides access to a verybroad network (NEEDHA)
- All the right players are involved

RATING: **Excellent**

APPENDIX B-1

ORGANIZATIONAL STRUCTURE FOR THE CAEME CENTER



1. IEEE, APS is the host society. President of AP-S is chair of the Policy Board. Membership includes:

   - NSF representative
   - IEEE executive office representative
   - CAEME Director
   - Designated representative from ADCOM of participating societies
   - Representative from sponsoring industries
   - NEEDHA representative
   - Corporate and Societies Development member

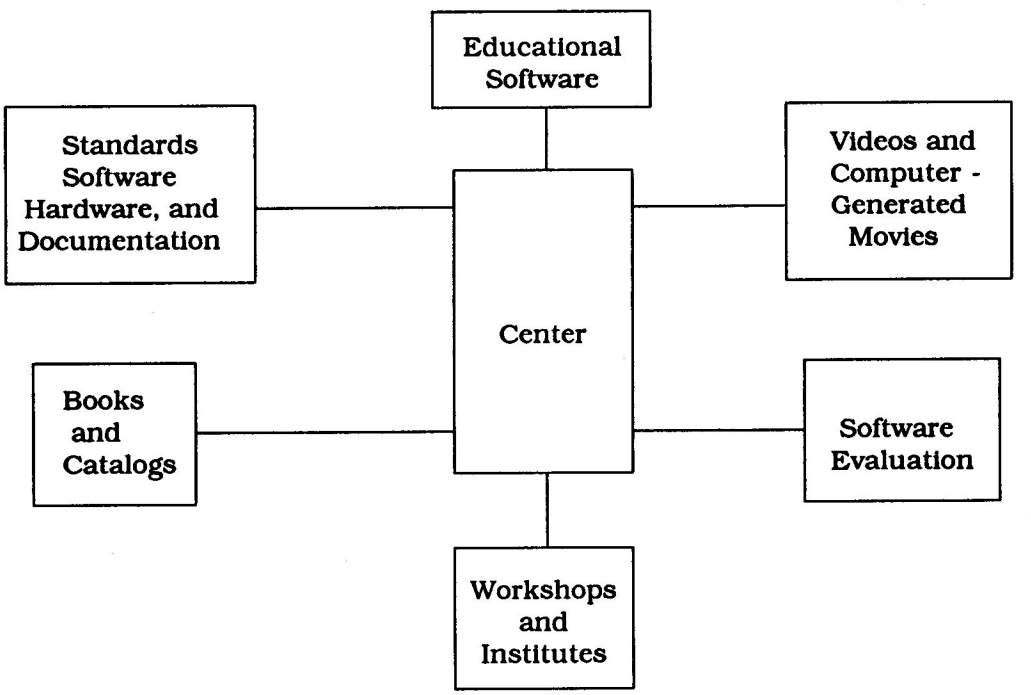
2. Distinguished members of IEEE participating societies.

3. CAEME Executive Committee consists of the Director and all chairs of subcommittees.

4. CAEME Center.

APPENDIX B-2

CAEME TECHNICAL ACTIVITIES AND PRODUCTS



Purpose of CAEME Center

- CAEME Center was established as a result of a grant from the Division of Undergraduate Science, Engineering, and Mathematics Education of the National Science Foundation.
- Objective: Stimulate and accelerate the use of computers to help boost electromagnetics education.
- Procedure:
  - -- Publish a catalog of available software and three books of tested and approved educational software packages.
  - -- Provide seed money to develop innovative computational systems and tools for education.
  - -- Hold workshops and training institutes (two per year) to report progress and exchange ideas.
  - -- Sustain inter-university cooperation and provide an effective mechanism for distribution under NEEDHA supervision.

APPENDIX B - 3

NSF/IEEE CENTER FOR

COMPUTER APPLICATIONS IN ELECTROMAGNETICS EDUCATION

CAEME

POLICIES AND OPERATIONAL PROCEDURES *

1. PURPOSE

The NSF/IEEE CAEME Center is established to stimulate, accelerate, and organize the use of computers in electromagnetics education. The Center is funded by the Division of Undergraduate Science, Engineering and Mathematics Education of the National Science Foundation, and managed by the Executive Office of the Institute of Electrical and Electronics Engineers (IEEE) on behalf of the Antennas and Propagation Society, the host society during the active period of the NSF grant. The Center's goals are to stimulate the use of computational system and tools in developing innovative techniques for teaching electromagnetics and to accelerate the integration of computing and advances in computer graphics into the electromagnetics curriculum. The CAEME Center will help sustain inter-university cooperation in the preparation of curricula and the creation of new and innovative educational aids. Under the terms of the NSF grant, the CAEME Center is expected to be active and self supporting after the three years (1989-1992) of NSF funding.

2. ORGANIZATION

The activities of the CAEME Center are reviewed, evaluated, and approved by a Policy Board. In addition, a group of independent technical advisors initially appointed by the IEEE, AP-S President, and added to as specified herein, will make recommendations to the Policy Board regarding focus and directions of these activities. The detailed operation of the Center is the responsibility of its director and is made according to the guidelines set by the Policy Board. The CAEME Director is also responsible for setting up subcommittees and task forces as needed to facilitate carrying out the various tasks and responsibilities. The director will be assisted by an executive committee which includes the chairs of the various subcommittees and task forces. A chart of CAEME organization is given in Appendix A. The distribution of the CAEME products is also a responsibility of the Center's Director. National Electrical Engineering Department Heads Association (NEEDHA) supervises the distribution of CAEME products.

3. POLICY BOARD

3.1 Purpose

The Policy Board is the governing body of CAEME, and has financial responsibility for its operations within the content of the NSF Grant.

The Policy Board insures proper liaison between CAEME and other IEEE and non-IEEE Societies and the industrial sponsors.

---

*These policies and procedures are being reviewed and revised by the CAEME Policy Board. Comments and suggestions are encouraged.

3.2 Membership

3.3 Duration of Membership

a. During the active period of the NSF grant, the Chair position on the Policy Board is for the position of the IEEE AP-S President. The individual occupying this position at any given time serves for the duration of the presidential term in accordance with the by-laws of the Antennas and Propagation Society. After the active period of the NSF grant, the chair will be elected from among the active board members.

b. The Chair of NEEDHA occupies a permanent position on the Policy Board. The individual occupying this position at any given time serves for the duration of the chair's term in accordance with the practices of NEEDHA. The NEEDHA Chair has the option to serve as a member of the Policy Board or to delegate this position to another NEEDHA member.

c. The CAEME Director and the corporate and societies liaison member serve three-year terms on the Policy Board. Membership of either on the Board may be extended for one additional year by majority vote of the Policy Board.

d. Each industrial sponsor or participating society may name one representative to the Policy Board from its own membership. Such individual representatives serve for a full term of three years subject to the continued society participation or company sponsorship. The term of these members may be extended for one additional year by majority vote of the Policy Board. No individual will serve more than four continuous years on the Policy Board.

3.4 Technical Advisory Committee

An important aspect of the CAEME Center is independent evaluation of its products and development. The Technical Advisors group is nominated by IEEE participating societies and appointed by the Policy Board. Members are appointed for a 3-year term. The Advisory Committee evaluates CAEME products, and recommends projects and focus of emphasis to the Policy Board. Such evaluations may be performed at the request of NSF, IEEE, or any of the participating societies of CAEME.

3.5 CAEME Center Director

The CAEME Center Director makes arrangements for meetings, authorizes expenses (according to budget guidelines), prepares and distributes the CAEME catalog, prepares, publishes, and distributes CAEME books, and coordinates two CAEME general workshops per year. The Director will also engage in discussions with interested societies and industrial sponsors who may be candidates for memberships. The Director will serve for a three-year term, plus one additional year by majority vote and will be compensated with 10 percent of his/her yearly salary.

The position of the center director is reserved for the PI on the NSF-funded project. After the active period of the NSF grant, the CAEME faculty elects the director from its current membership. Final appointment is made by the Policy Board.

3.6 Quorum

Two thirds of the members of the Policy Board need to be present to form a quorum.

4. CAEME FACULTY

4.1 Purpose

The CAEME faculty is responsible for carrying out tasks, projects, and for the delivery of CAEME products. CAEME faculty may be either a member of one of the ongoing subcommittees and task forces, or an individual working on a CAEME--sponsored project. Since the purpose of CAEME is to sustain inter-university cooperation in developing and sharing software for undergraduate electromagnetics education, the organization of the CAEME Center reflects a focus on achieving this goal.

4.2 Membership

It is a goal of the CAEME Center to have representatives from all ABET-accredited Electrical Engineering Departments with research or instructional efforts in developing computer-generated teaching aids and/or computer-aided design and analysis of electromagnetics problems for use in undergraduate education. Industrial members will also be sought to provide an important practical perspective to CAEME projects. Additional membership may be requested for adequate Society representation.

a. Recommendation by a majority vote of active CAEME members;

b. Assurance that there is no more than one member from a single university, company, or government laboratory/office. The term of membership is three years.

c. Membership will be renewed at the same time yearly and automatically expires with the completion of a specific CAEME project and the dissolution of a subcommittee.

4.3 Executive Committee

The Executive Committee consists of the Center Director and the chairpersons of the sub-committees and task forces. The Center Director may add to the executive committee one or two members at large to assist him in carrying out the Center's tasks and long-range plans.

All individuals holding seats on the Executive Committee are to be working CAEME members engaged in the development of software or other products for electromagnetics undergraduate educa tion. Membership of the executive committee is renewed yearly and automatically expires with the completion of the tasks of any subcommittee.

The responsibility of the Executive Committee is to report to the Center Director its sub-committee findings and progress, and to suggest changes as needed to accomplish their tasks. The budget requests of the subcommittees and any changes in their procedures should be approved by the Director.

4.4 Accounting

Accounting reports will be made to IEEE Headquarters, to the treasurer of participating societies, and to the representative of any other participating entity that requests it.

5. PARTICIPATION AND SPONSORSHIP

5.1 IEEE Electromagnetics Based Societies

CAEME welcomes participation by all IEEE electromagnetics-based Societies and other IEEE Societies that may be interested in electromagnetics education. A fee determined by the number of members in the Society is required.

a. For Societies with more than 3,000 members, the yearly membership fee is $5,000.

b. For Societies with less than 3,000 members, the yearly fee is $3,000 per year.

5.2 Non-IEEE Societies

Participation by non-IEEE Societies must be approved by the Policy Board of CAEME subsequent to review and recommendation by the General Manager of the IEEE. Membership fees similar to those of IEEE Societies will apply.

5.3 Industrial Sponsorship

In the first year, a flat fee of $5,000 per year will be charged to each industrial sponsor. In return, the sponsors get copies of CAEME's products, and may participate in its workshops and institutes. After the publication of the first CAEME book, the membership structure will be as follows:

a. Full members: Each will be charged a yearly fee of $10,000.

b. Associated members: This grade will be reserved for small businesses with annual sales of less than $5,000,000. A membership fee of $5,000 per year will be charged. Associated members are entitled to CAEME products and to a non-voting seat on the Policy Board.

5.4 Electrical Engineering Departments

Due to the NSF sponsorship, CAEME catalog and the first three books will be distributed free of charge to all ABET-accredited EE Departments. In the second year, a voluntary fee of $500 per year will be solicited to initiate efforts towards achieving a self-supporting CAEME Center. After the active period of NSF funding, CAEME products will not be sent to non-member EE Departments.

6. SUBCOMMITTEES AND TASK FORCES

To help the director of the Center carry out CAEME projects, the Executive Committee may establish one or more subcommittees and Task Forces of one or more persons each. Examples include the Finance, Publications, New Projects, Standards, and Evaluations Subcommittees. The director, in collaboration with other members of the Executive Committee may recruit for and appoint to subcommittees and Task Forces members who are not necessarily members of the CAEME faculty. The Executive Committee will have the authority at any time to fill vacancies in any such Subcommittee or Task Force, to change their membership or to discharge the Subcommittee or Task Force. The responsibilities of Subcommittees are as follows:

a. **New Projects Subcommittee:**

Study and develop ideas for instruction in undergraduate electromagnetics.

b. **Standards Subcommittee:**

Help develop mechanisms to encourage software developers to adhere to recommended standards; encourage convertibility between systems developed at different universities

c. **Publication Subcommittee:**

Prepare the CAEME books, conduct software testing, and evaluate the end products. Terms of members expire with the completion of a specific projects.

d. **Finance Subcommittee:**

Plan, coordinate, and direct CAEME fund-raising activities, establishing liaison with IEEE and non-IEEE electromagnetics-based societies, societies interested in education, and with potential industrial sponsors. No departures from the established fee structure (item 3) will be made without approval of the Policy Board. In all cases, final membership approval will be the prerogative of the Policy Board. This subcommittee is also responsible for recommending to the Director steps towards making CAEME a self-supporting Center.

e. **Evaluations Subcommittee:**

Identify available software packages suitable for evaluation by CAEME and recommendation of test sites for carrying out the evaluations.

7. MEETINGS, CONFERENCES, AND WORKSHOPS

The CAEME Center will hold two two-day meetings annually for general coordination, review of subcommittee activities, and report of new developments by members. The meetings will be held in conjunction with symposia of the participating societies.

Additional one-day workshops and/or training institutes will be held as needed. Workshops will be organized to address and coordinate various aspects of CAEME activities. Disbursement of the proceeds from these workshops will be negotiated with the appropriate AdComs of societies on a case-by-case basis. The workshop proceeds will be used to support the center activities.

8. GRANTS AND CONTRACTS

The CAEME Center will provide seed funds to encourage research and development of new software for undergraduate education in electromagnetics. In addition to the NSF grant funds, CAEME may choose to use some of the funds raised from Society participation and industrial sponsorship to support its curriculum development activities. Such use must be approved by the Policy Board.

a. The New Projects Subcommittee has responsibility for identifying critical needs of software in classrooms and avenues to take advantage of the rapidly expanding computer technology.

b. The CAEME Director presents the New Projects Subcommittee's findings to the Policy Board and requests a budget to carry out the recommended projects.

c. With the approval of the Policy Board, advertisements of availability of grants (requests for proposals) and areas of interest will be placed in the AP-S Newsletter, Newsletters of the participating societies, and in the IEEE Institute. Copies of the advertisement will be sent to all ABET-accredited Electrical Engineering Departments through NEEDHA's distribution system.

d. Shortly after the proposals deadline, the Subcommittee on New Projects will meet, review, and prioritize the received applications.

e. The recommendations of the subcommittee will be submitted to the CAEME Director via the subcommittee chair.

f. The CAEME Executive Committee makes recommendations, prepares, and submits the budget to the Policy Board via the CAEME Director.

g. The Policy Board, at its option or at the request of the National Science Foundation Directorate for Science and Engineering Education, may seek the guidance of the group of independent Technical Advisories in evaluating the recommendations. The Policy Board makes final decisions and announces the grant awards.

h. Members of the New Projects Subcommittee may be appointed to serve in technical liaison roles on these grants. Otherwise, the CAEME Director will assume this responsibility.

i. Funds for the amount approved by the Policy Board will be allocated for use by the Principal Investigators of these grants, according to the approved itemized budgets. Project expenditures are monitored by the CAEME liaison and are reported to the CAEME Treasurer.

9. PRODUCTS AND DISTRIBUTION

The main CAEME products are a software catalog and three books to be published during the three years for which NSF funding has been provided.

9.1 Catalog and Books

CAEME will prepare a catalog of available software, its sources, and a brief description of its function. Copies of the catalog will be distributed on diskettes.

Plans for the preparation and publication of the CAEME books will start immediately after the preparation of the draft of the catalog. A Publication Subcommitee will work with the Execuive Committee to determine software to be included in these books. Computer codes with broad utilization, of significant impact on undergraduate education, suitable for teaching fundamentals of electromagnetic theory, will be converted to hardware and software standards set by CAEME and sent for review to selected test sites. Upon evaluation of results from classroom testing, suggestions will be made to authors to assist their final preparation of the manuscript to be published in the book.

9.2 Distribution

a. NEEDHA will provide a focus for distributing information about CAEME activities and opportunities. This includes notices of conferences and work shops, request for proposals, advertisements for participation as test sites, and availability of CAEME products. In addition to NEEDHA's involvement, this information will also be regularly advertised in the Newsletter/Magazine of AP-S

those of other participating societies and in the IEEE Institute.

b. It will be the responsibility of the CAEME Director to distribute CAEME products. The NSF grant provides some support for secretarial assistance and supplies for the CAEME Director. The Director will cooperate with and obtain the approval of the NEEDHA Chair on all distribution matters. The NEEDHA Chair will play a supervisory role and assist the Center Director in the distribution of CAEME products, including providing distribution lists, notes of additional requests, changes of names and addresses, etc.

10. **AMENDMENTS**

These policies and procedures may be amended, added to, or repealed, in whole or in part in accordance with Robert's Rules of Order.

APPENDIX C

Call for Contribution to the CAEME Catalog

The NSF/IEEE CAEME Center for Computer Applications in Electromagnetics Education is developing a comprehensive catalog of available EM educational software. This catalog will be distributed on diskettes free of charge to all ABET-accredited Electrical Engineering Departments, and to particiatesof the AP-S, MTT-S, and ACES Symposia. Listing in the catalog provides a valuable opportunity tc advertise your software, and contact colleagues who have software of interest to you. If you have or know of an EM educational software package and want to list it in the CAEME Catalog, please call or send the information to:

Dr. Magdy F. Iskander
Electrical Engineering Department
3280 MEB
University of Utah
Salt Lake City, Utah 84112 (801) 581-6944

For listing in the catalog, the following information is required:

-- Title of software

-- Name and address of author(s)

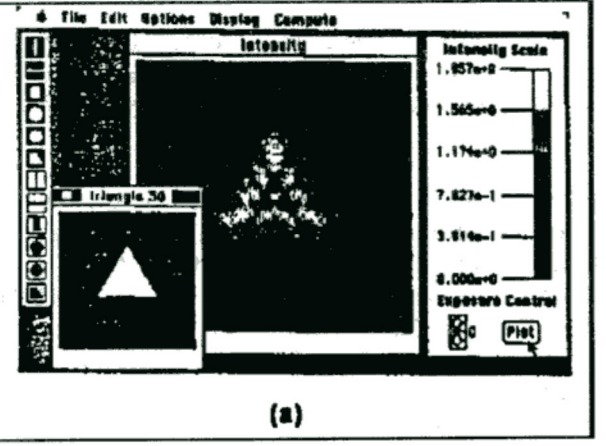
-- Availability

-- Description of capabilities

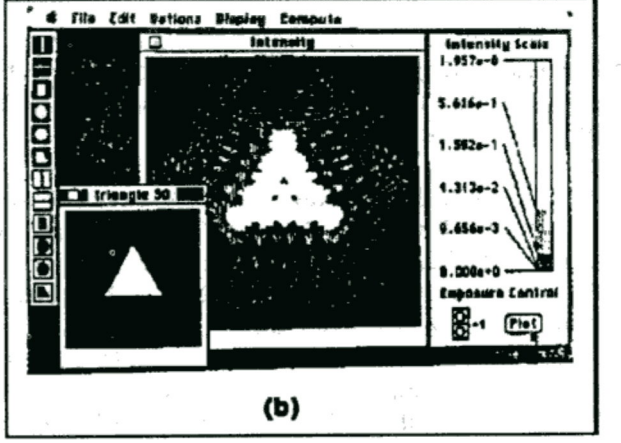
-- Hardware platform

-- Fee, if any

We wish to include illustrative examples for each listed package. The following sample example is included for reference:



(a)



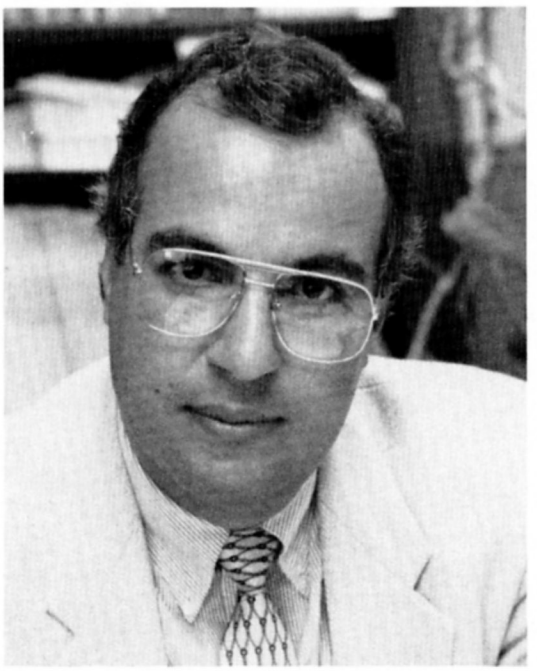
(b)

For additional information, please contact Dr. Iskander.

Magdy F. Iskander was born in Alexandria, Egypt, on August 6, 1946. He received the B.Sc. degree in Electrical Engineering from the University of Alexandria, Egypt, in 1969. He received the M.Sc and Ph.D. degrees in 1972 and 1976, respectively, both in Microwaves From the University of Manitoba, Winnipeg, Canada.

In 1976, he was awarded a National Research Council of Canada Postdoctoral Fellowship at the University of Manitoba. Since 1977 he has been with the Department of Electrical Engineering and the Department of Bioengineering at the University of Utah, Salt Lake City, where he is currently a Professor of Electrical Engineering and a Research Professor of Materials Science and Engineering. In 1981, he received the University of Utah President David P. Gardner Faculty Fellow Award and spent the academic quarter on leave as a Visiting Associate Professor at the Department of Electrical Engineering and Computer Science, Polytechnic Institute of New York, Brooklyn. He spent the summers of 1985 and 1986 at the Chevron Oil Field Research Company, La Habra, CA, as Visiting Scientist. From September 1986 to May 1987 he spent a sabbatical leave at UCLA, where he worked on the coupling characteristics of microwave integrated circuits to inhomogeneous media. He spent the last four months of the sabbatical leave with the Ecole Superieure d'Electricite, Gif-Sur-Yvette, France, where he worked on microwave imaging. His present fields of interest include the use of numerical techniques in electromagnetics to calculate scattering by dielectric objects, antenna design for medical applications, microwave integrated circuit design, and the use of microwave methods for material characterization and processing.

Dr. Iskander edited two special issues of the Journal of Microwave Power, one on electromagnetics and energy application (March 1983), and the other on electromagnetic techniques in medical diagnosis and imaging (September 1983). The holder of seven patents, he has contributed seven chapters to five research books, published more than 85 papers in technical journals, and made more than 150 presentations at technical conferences. In 1983, he received the College of Engineering Outstanding Teaching Award and the College Patent Award for creative, innovative, and practical invention. In 1984, he was selected by the Utah Section of the IEEE as the Engineer of the Year. In 1984 he received the Outstanding Paper Award from the International Microwave Power Institute, and in 1985 he received the Curtis W. McGraw ASEE National Research Award in outstanding early achievements by a university faculty member. In 1986 Dr. Iskander established the Engineering Clinic Program in the College of Engineering at the University of Utah. Since then the program has attracted 23 research projects from 11 different companies throughout the United States. He is also the Director of the NSF/IEEE Center on computer applications in electromagnetics education.



EM Modeling Notes

G. J. Burke

Not much has been happening in NEC developments lately. We are waiting for more $$ to finish and document NEC-4. Also my home projects on the Macintosh were set back by a disk disaster. However, we have received a few reports of errors and suggestions for modifications to NEC that I can pass along.

The Macintosh story might be of interest to anyone contemplating buying a personal computer. As I said in the June 89 Newsletter, I bought a Macintosh SE/30 in April with a 80 megabyte disk. There have since been reports of trouble with the disks that Apple was putting in the Macs around that time, in particular those made by Quantum. The usual problems are attributed to the lubricant absorbing moisture and sticking the head actuator arm. Hence the trouble is expected to be more common in areas with high humidity, which we do not usually have in Livermore. Unfortunately, the problem often appears outside of the 90-day warranty that Apple provides. Apple has developed a fix in which a new PROM is installed that increases the torque on the actuator and initiates additional seeks when the computer is idle to keep the arm loose. The PROM upgrade is provided for free for disk drives in the subject serial number range, but Apple does not provide any other coverage for drives out of warranty.

My disk worked OK for six months until I was away for a month in October. When I started up the Mac after a month off it at first could not boot from the disk, but after I turned it off and on, it got going on a second try. It worked ok for two more weeks, but then, on Thanksgiving weekend, it made a strange noise when I tried to save a file, and stopped working. The repair shop ordered and installed the Apple PROM but it did not fix the problem. Finally they decided I needed a new disk, so I was out $800 as well as losing the use of the computer for six weeks over the holidays. Fortunately they were able to save most of the data. I got another 80 megabyte Quantum drive, this time with a one year warranty from Quantum. We were unable to determine whether the problem with the old one was sticky lubricant or some other failure.

I guess the moral is that, unless Apple starts offering a one year warranty like most other PC makers, one should get a stripped down model and buy the disk, additional memory etc. from the original makers. That way you usually get a one year warranty. Apple also gets a one year warranty on most components, but only passes along the 90-day warranty with their products. This questionable practice is discussed in an article in the December 1989 issue of MACWORLD.

While a number of people I work with have Macs in use, many coming from the time period when these problem disks were released, there have apparently not been any certified cases of the head actuator sticking. However there are several cases, just in my building area, where the disk has trouble spinning up after it has been off for a while. One person has to open his up and give the flywheel a nudge on Monday mornings. Also there are reports of Apple supplying new disk drives for ones that have failed past the 90-day warranty, but only to their large customers. Too bad for the little guy. Rumors suggest that Apple will eventually be forced offer one year warranties. Until then, buyer beware!

I have received several inquiries from people interested in the NEC-3 version for Absoft's MacFortran/020. Unfortunately we cannot send this out at the present time due to the Defense Critical Technology restriction. People in DoD are afraid that once a code got out on floppy disks it would be uncontrolable. I think a lot of people are doing their own conversions, however. It is much easier for large Macs and 386 PCs than it was when the code had to be squeezed into 640k with a limited compiler. However there was one additional problem that I found after writing the last column. The output formats in subroutine PRNT, constructed from Hollerith constants, caused the code to crash. I had to write PRNT over using character strings. If anyone is interested in NEC-2 for MacFortran, we could send that.

I have also converted DIGLIB to run on the Macintosh under MacFortran/020. DIGLIB stands for Device Independent Graphics Library, and was developed at Livermore by Hal Brand. It is device independent because it uses only low level functions of any graphics device, and includes its own character fonts, scaling, etc. For a new device you just have to write a driver that will initialize the device,

return the device characteristics, clear the plotting surface and move the "pen" around. Support for other features such as color, fill patterns and graphics input is optional. DIGLIB is relatively crude by the standards of modern computer graphics, but it is public domain software and is written entirely in Fortran. It is used by NECPLOT to display models from NEC input or output files and is the graphical basis of the SIG signal processing program developed at Livermore. It will do 2-D plots, linear or log, with one or two y-axes, and has routines for 3-D and contour plots. So far I have written drivers for the Mac screen and HP 7475 plotters. We still need a driver for the Apple Laser Writer. I could send this out, although the routines still need to be sorted so that they will link as a library in one pass of the Absoft linker.

On the subject of programs for the Macintosh, another program available from Livermore is VIEW, an image analysis and display program. View is a successor to the signal processing code SIG, and includes many operations for display, manipulation and simulation of 1-D or 2-D signals. It is menu or command driven and offers online HELP. It was written in the C language and is supported on VAX and Sun as well as Mac II computers. One excellent feature is that it is available at no cost. The contact for information or ordering is Donna Barnhouse, L-97, Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550. Ed Miller summarized the capabilities of View in his column in the December 1989 IEEE APS Newsletter.

We have received a couple of error reports from NEC users since the last Newsletter. I realize I should compile all of the error corrections over the last few years, but that can be a subject for a subsequent issue.

Dr. Guy Morgan at Culham Laboratory in England discovered an error when the Numerical Green's Function is used in the double precision NEC-2D or NEC-3D on a structure with patches. The error results from the use of EQUIVALENCE to let integer arrays ICON1, ICON2 and ITAG and real arrays T2X, T2Y and T2Z share space in common block /DATA/. To maintain alignment when the double precision real length is twice that of an integer, as on the VAX and many other computers, the dimensioned length of these integer arrays had been doubled. The problems that Dr. Morgan found were in subroutines GFIL and GFOUT, where the integer names were used in READ and WRITE statements where the intent was to transfer the real values. To correct this problem the statements

```
DIMENSION T2X(1), T2Y(1), T2Z(1)
EQUIVALENCE (T2X,ICON1), (T2Y,ICON2), (T2Z,ITAG)
```

should be added to both subroutines GFIL and GFOUT. In GFOUT, the statements at lines GO 38 and GO 39 should be changed to read

```
WRITE (IGFL) (T2X(I), I=J, LD), (T2Y(I), I=J, LD)        GO 38
WRITE (IGFL) (T2Z(I), I=J, LD)                           GO 39
```

while in GFIL the statements at lines GI 55 and GI 56 should be

```
READ (IGFL) (T2X(I), I=J, LD), (T2Y(I), I=J, LD)         GI 55
READ (IGFL) (T2Z(I), I=J, LD)                            GI 56
```

This change is not necessary in the single precision codes, but will not hurt. Dr Morgan also reported a modification to combine a reflection plane with rotational symmetry in NEC by generating a hybrid transformation matrix in common /SMAT/.

Another error was encountered by Grant Bingeman at Continental Electronics. He found that division by zero may occur when the electric field is evaluated exactly on the axis of a wire segment. This happens only when the extended thin-wire kernel (EK command) is in use and the code switches back to the thin-wire kernel at a bend in the wire. The division by zero occurs in evaluating the radial electric field which is zero anyway on the axis. The fix is not to do the calculation, since the thin wire approximation is not valid for radial electric field closer to the wire axis than the wire radius. In NEC-3

the statements

```
GR1=GZ1/RHX                                    EX 37
GRP1=GZP1/RHX                                  EX 38
```

at lines EX 37 and EX 38 should be replaced by

```
IF(RHX.GE.BX)THEN
      GR1=GZ1/RHX                              EX 37
      GRP1=GZP1/RHX                            EX 38
ELSE
      GR1=0.
      GRP1=0.
END IF
```

The same changes must be made to lines EX 46 and EX 47 in computing GR2 and GRP2. In NEC-2 the same changes should be made at lines EX 35, EX 36 and EX 44, EX 45.

We received two reports of NEC-2 giving incorrect values for magnetic field (NH command) near ground in the Sommerfeld-Norton mode. Actually NEC-2 does not use the Sommerfeld solution for magnetic near field, but this is not very obvious from reading the manual. It only evaluates the direct field and reflected field using the reflection coefficient approximation. The typical result is field values that are too small near the interface. NEC-3, in the Sommerfeld mode, gets magnetic near field from a finite difference evaluation of the curl of E, although neither NEC-2 nor NEC-3 use Sommerfeld in a MFIE patch model. If anyone with NEC-2 needs to compute magnetic field due to wires over ground I can send a listing of subroutine NHFLD modified to evaluate the curl of E when Sommerfeld is in use.

Adrian Hamilton at Hunting Engineering Ltd. in England reported several modifications made to NEC. They have added a PR command to suppress printing of current on surface patches. The PT command does this for wires but not patches. They also have modified the code that prompts for and reads the names of the input and output files. Currently if an error occurs, such as the input file cannot be found, the code displays an error message and asks for the file name again. This is fine if you are running an interactive job, but if you make an error in a file name in a batch job on a VAX the code may fill up all available disk space with error messages. Adding a counter to stop this process after a reasonable number of tries is a good solution.

Hunting Engineering has also struggled through increasing the array dimensions to handle more segments and patches. I have gotten tired of this process also, and changed to using parameters for dimensions. This can be done fairly easily if all dimensions of 300 are changed to MAXSEG, 600 to 2*MAXSEG and 900 to 3*MAXSEG. The line breaks in COMMON /DATA/ must be changed to stay within 72 columns, but this is not too bad. On the VAX you can change one COMMON/DATA/, then cut it into the Past buffer, search for "/DATA/", past the new version and delete the old one using "Delete Line." The line LD=300 in the main program should also be changed to LD=MAXSEG. In subroutine RDPAT you can add PARAMETER (NORMAX=4*MAXSEG) and use NORMAX as the dimension for the real array GAIN. Then delete the DATA statement setting NORMAX. In MAIN, GFIL and GFOUT, I put a statement PARAMETER (IRESRV=MAXMAT**2). Then the final steps are to put something like INCLUDE 'NEC2S.PAR' in each subroutine using either MAXSEG or MAXMAT, and create an include file NEC2S.PAR with PARAMETER (MAXSEG=600, MAXMAT=600), or what ever you need. Of course you can change the other dimensions, such as number of sources, to parameters if you want, but the maximum segments and matrix size are probably the most frequently changed. Unfortunately the VAX requires quotes around the file name in an INCLUDE statement and MacFortran does not allow them. This is an easy change, however, especially with only one INCLUDE file. The whole process takes less than half an hour. Then all you have to do is edit the INCLUDE file and recompile.

RENDEZVOUS WITH A COMPUTER SCIENTIST

Software Testing

Virginia Stover

The following is from *ACM's Software Engineering News*, Jan. 1989:

In late 1983 Blue Cross and Blue Shield United of Wisconsin hired Electronic Data Systems to build a $200 million computer system. It was ready 18 months later on time. But it didn't work. The system spewed out some $60 million in overpayments and duplicate checks before it was harnessed last year. By then, Blue Cross says, it had lost 35,000 policy holders.

From the *San Francisco Chronicle*, Sept. 10, 1988:

The Soviets lost their Phobos I spacecraft after it tumbled in orbit and the solar cells lost power. The Soviet Mars probe was mistakenly ordered to "commit suicide" when ground control beamed up a 20 to 30 page message in which a single character was inadvertently omitted. The commands caused the spacecraft's solar panels to point the wrong way, which would prevent the batteries from staying charged, ultimately causing the spacecraft to run out of power.

From an article by John Lamb in the *New Scientist*, Sept. 8, 1988, about the software used for air traffic control in the London Area by the Civil Aviation Authority:

The National Airspace Package, designed by IBM's Federal Systems division, contains a model of the airspace it controls, that is, a map of the airlanes and beacons in the area. But, because the program was designed for air traffic control centres in the US, the designers had taken no account of a zero longitude; the deficiency caused the computer to fold its map of Britain in two at the Greenwich meridian, plonking Norwich on top of Birmingham.

From an article in the *Washington Post*, Sept. 20, 1989:

About 100 hospitals around the country, including Washington Hospital Center, were forced yesterday to switch from computers to pen and paper for major bookkeeping functions because a software program could not figure out what day it was. The incident affected hospitals that use software and services provided by a Pennsylvania company called Shared Medical Systems Corp. Due to a fault in the aging software, the machines were unable to accept as valid the date September 19, 1989, and went "into a loop", refusing to work, spokesman A. Scott Holmes said. By day's end, computer services at about 100 of SMS's 600-700 client hospitals had been disrupted. [A little analysis shows that 19 Sept 1989 is exactly 32768 days after 1 Jan 1900, a number of days that happens to be 2^{15}].

From *Software Engineering News*, July 1988:

During the week of 2 May 1988 while the House of Representatives was voting on a funding bill for the Strategic Defense Initiative, the House vote-tallying computer broke down. The computer reported a vote of 358 ayes and 237 nays on an amendment to kill the SDI program offered by Reps. Don Dellums and Barbara Boxer. The House only has 435 members. The irony was not lost on the opponents of the SDI. Nevertheless, the "manual" count of voice votes revealed defeat of the amendment 299-118.

Simon's Law

Everything put together falls apart sooner or later.

It is easy to write programs. It is hard to write programs that behave correctly all the time. These examples point out the inadequacy of current software validation methods. The method most often used to validate software is testing. Testing involves executing a program over a set of input values for which the outputs are known. Output values are calculated and compared against the expected output. The program fails if the computed output does not match the expected output.

The problem with testing is that it is often done haphazardly. Often no systematic method is used to select the input data or to determine the number of tests needed. Testing stops when the project runs out of time or the testers get bored. Usually no attempt is made to measure the effectiveness of the testing effort or the quality of the final software product. Clearly a more rational approach to testing is needed.

Exhaustive Testing

Lubarsky's Law of Cybernetic Entomology

There's always one more bug.

Since a computer is a finite machine with a finite amount of storage, each program has only finitely many different input streams. Therefore, it is theoretically possible to test every input stream. In practice, however, even for simple programs, the set of possible input streams is too large. For example, a program that accepts a 10-character input string has approximately 2^{80} possible inputs. If it took just 1 microsecond to test each one, it would take approximately twice the current age of the universe to complete all the tests! For this reason, testing alone cannot prove that a program is correct. Instead of a proof of correctness, we must be content with a "suitably convincing" demonstration.

Control-Flow Coverage Methods

In deciding when to stop testing, it should be obvious that enough tests should be performed so that each statement in the program is executed at least once. Testing will not reveal an error in a statement if that statement is never executed. The requirement that each statement be executed by at least one test is called "statement coverage". Statement coverage seems to be necessary, but it is certainly not sufficient. Consider the following example:

```
INPUT X
IF X > 0 THEN Y = 5
Z = Y
```

Only one test, say at X = 1, suffices to execute each statement once. But this code does not work correctly when X < 0 since Y's value will be undefined. This error will be uncovered by testing only if the false branch of the IF statement is executed. Thus, testing each statement is not enough. It is necessary to execute each branch of each statement at least once. This criterion is called "branch coverage."

Branch coverage will detect many errors that statement coverage does not. Some errors, however, may only be detected by executing certain combinations of branches. For example, two tests, say (X = 1, Y = 1) and (X =- 1, Y = -1), are sufficient to execute each branch of the following two statements:

```
IF X > 0 THEN Z = 10 ELSE Z = -1

IF Y > 0 THEN Z = Z + 1 ELSE Z = Z - 1
```

But these two tests do not check all combinations of branches. In addition, we need to test the cases (X > 0 and Y < 0) and (X < 0 and Y > 0).

As another example, suppose we wish to add the first N elements of an array A with the following code:

```
SUM = 0
I = 1
WHILE (1 < = N) DO
SUM = A [I]
I = I + 1
END WHILE
```

The WHILE statement contains a two-way branch. If I < = N, then the statements inside the loop are executed. If I > N, then control transfers to the statement following the end of the WHILE loop. This program fragment works correctly when N < 1. In this case the loop is bypased, and the correct sum (SUM = 0) is computed. When N = 1 the statements inside the loop are executed once, and again the correct sum (SUM = A [1] is computed. These tests cover both branches of the WHILE statement. But this program fragment does not work correctly when N > 1 and the loop executed more than once. Thus, traversing every branch is not sufficient. Every path through the program should be executed at least once. This is the "path coverage" criterion.

Gilb's Fourth Law of Unreliability

Investment in reliability will increase until it exceeds the probable cost of errors, or until someone insists on getting some useful work done.

Complete path coverage is difficult to achieve for several reasons. First, there may be an infinite number of paths through a program containing a loop. It is common in path coverage testing to specify an upper limit to the number of loop repetitions, say all loops should be tested over 0, 1, and 2 iterations. This, of course, does not detect failures that occur only when a loop is iterated a large number of times. Second, even if loops are iterated no more than two times, the number of paths can be enormous. In fact, the number of paths grows exponentially as a function of the number of branches (A program that has n two-way branches has 2^n possible paths). It is not uncommon for complete path coverage to require testing times measured in centuries. Third, it can be very difficult in large, complex programs to select input values that cause a particular path to be traversed. In fact, it may not be possible to execute certain paths. The logical conditions that cause the required branches to be followed are contradictory. Such paths are said to be "infeasible". For example, the path that iterates the following outer FOR loop once and the inner FOR loop twice is infeasible since the two loops must be iterated the same number of times.

```
FOR I = 1, N
        FOR J = 1, N
                A [I,J] = B [I,J] + C [I,J]
        END FOR
END FOR
```

Infeasible paths can be quite common. A study of 6 numerical analysis library routines found that an average of only 18 out of the first 1,000 shortest paths were feasible! [7] The problem with infeasible paths is that they can be very difficult to detect, and a lot of time can be wasted looking for input values that cause a particular infeasible path to be executed. Finally, path coverage testing will not uncover certain types of errors. In particular it will not detect errors in missing paths. If a statement contains a divide-by-zero error, for example, we may fail to test the case in which the denominator is zero unless there is a separate branch to take care of that case.

For these reasons path coverage testing is usually confined to individual procedures or subroutines. At the system level complete full path coverage is rarely achieved, and it is more common to require only the coverage of some fixed percentage of all program paths.

Actually, the goal of control-flow coverage is to execute each *function* computed by the program at least once. The functions that a program is to compute are identified in the requirements, specification, and design phases of the software's development. They can be expressed in the form of a mathematical formula, English language description, decision table, state transition diagram, flow graph, etc. By confining testing to explicitly testing just these functions, testing can be reduced to a reasonable size. It is often difficult, however, to identify a function once it is embedded in the code. A function need not beconfined to a single module or other program construct, and it may span several paths or subpaths. Therefore, the use of control constructs for identifying embedded functions has not been very successful. A more promising approach is the use of data flow.

Data-Flow Coverage Methods

In data-flow testing, functions are identified, not by the flow of control through a program, but by the flow of data. The idea is that statements that access related data probably are part of the same embedded function. For example, suppose statement S_1 assigns a value to a variable X, and subsequently statement S_2 references the value of X. Then at least one test should execute S_1 followed by S_2. The subpath from S_1 to S_2 is called a "definition-use" chain or "du-chain" for short. Enough tests should be performed so that each du-chain for each variable is executed at least once. In addition, longer subpaths can be tested by selecting a sequence of consecutive du-chains for the same variable. Experimental evidence suggests that the number of paths needed to cover all du-chains is usually significantly less than the total number of all program paths. [1]

Control flow and data flow coverage testing for programs of even moderate size require an automated testing tool. Tools exist that will automatically execute a program over a set of input values, check the computed output against the expected output, keep track of which paths have been traversed, report those that have not been covered, and, if possible, suggest input values that will cause a particular path to be executed.

Software Metrics

Gilb's Third Law of Unreliability

Undetected errors are infinite in variety, in contrast to detectable errors, which by definition are limited.

The methods discussed so far define test termination in terms of program coverage. Alternatively, termination can be defined in terms of error coverage, that is, detecting and correcting a certain percentage of all errors. This requires an estimate of the number of errors remaining in a program. The number of errors is a function of the program's size and complexity. The larger and more complex the program, the more errors we would expect. Several metrics have been proposed to measure program size and complexity. Some of the more well-known measures are due to M. Halstead.

Halstead's metrics are based on the number of operands (variables and constants) and the number of operators (arithmetic and relational operators, control constructs, etc.) contained in a program. His formula for the number of errors in a program after compilation (that is, after syntax errors have been removed) is

$$(N_1 + N_2) \log_2 (n_1 + n_2) / 3000$$

where

N_1 is the number of operators
N_2 is the number of operands
n_1 is the number of distinct operators
n_2 is the number of distinct operands

For example, a program with 90 operators, used a total of 1200 times, and 166 operands, referenced 1500 times should have approximately $(1200+1500) \log_2 (90 + 166)/3000 = 7.2$ errors. Many experiments have verified Halstead's metrics for programs over a wide range of sizes.

Mutation Testing

Zymurgy's First Law of Evolving System Dynamics

Once you open a can of worms, the only
way to recan them is to use a larger can.

Mutation testing is another method for estimating the number of errors in a program. As noted above, if a statement is never executed, we can introduce a fault into that statement without changing the test results. This is the idea behind mutation testing. Mutation testing is performed by repeatedly seeding the program with one or more errors. Each test case is run on each of the modified programs. The number of seeded and unseeded errors detected is recorded. Since the ratio of total errors to detected errors should be about the same for both seeded and unseeded errors, the number of unseeded errors remaining in the program can be estimated by the formula

$$N_u = N_{ud} \frac{N_s}{N_{sd}}$$

where

N_u is the total number of unseeded errors
N_{ud} is the number of unseeded error detected
N_s is the total number of seeded errors
N_{sd} is the number of seeded errors detected

This gives a measure of the adequacy of the test suite. Enough tests should be run so that each introduced error is revealed by at least one test.

Partition Testing

Churchill's Commentary on Man

Man will occasionally stumble over the truth, but most
of the time he will pick himself up and continue on.

All of these methods belong to a general family of testing strategies called "partition testing". Partition testing divides the input domain into several, possibly overlapping, domains. Ideally testing should include at least one element from each domain. In statement coverage, each domain consists of the inputs that cause a particular statement to be executed. In branch coverage, each domain consists of the inputs that cause a particular branch to be traversed. In both cases, the domains may overlap. In path coverage, each domain consists of the inputs that cause a particular path to be traversed. These domains are necessarily disjoint, since two different paths cannot be traversed on the same input. Mutation testing defines domains based on the inputs that cause a particular seeded error to be detected. Exhaustive testing can be thought of as partition testing in which each input belongs to a separate domain.

Troutman's Fifth Programming Postulate

If the input editor has been designed to reject all bad input, an ingenious idiot will discover a method to get bad data past it.

Actually, covering each partition is not enough. Errors may be revealed by some, but not all, input values from a particular partition. In order to detect faults in the path predicate of a branch statement, for example, it is important to use input values that cause different values to be computed on different branches. The following should be executed over values of X other than 0 or 2, since X + X and X * X will have the same value there.

```
IF I  > = 3 THEN
        Y = X + X
ELSE
        Y = X * X
END IF
```

In addition, it is critical to check values *at and near* the boundary of partitions. By executing the above statement at I = 2, 3, and 4, we can detect an error in the operator (">=" instead of ">") or in the constant ("3" instead of "2").

Statistical Testing

Finagle's Fifth Rule

Experiments should be reproducible, they should all fail in the same way.

Statistical testing is a form of "black-box" testing in which no information about the program's structure is used. In statistical testing input values are chosen at random. The more random tests are performed without failure, the greater our confidence should be that the program is error-free. Testing stops when the failure rate drops below a certain predetermined threshold.

Let p be the probability that a program will fail on some randomly chosen input. Let's hypothesize that the failure rate is below 1/h for some large value h. That is, we want to test the hypothesis that $p < 1/h$. Let's test this hypothesis by executing the program over n randomly chosen input values. We will accept the hypothesis if and only if the program does not fail on any of the n inputs. That is, we will say our program is "good enough" if all n computed outputs match the expected outputs. What is the probability that we wrongly accept the hypothesis (i.e., stop testing when we shouldn't)? We incorrectly accept the hypothesis if $p >= 1/h$ and the program does not fail on any of the n tests. The probability that this occurs is $(1 - p)^n$. It can be shown that this probability is less than 1/h if $n > h\ln(h)$. Thus, $h\ln(h)$ tests are sufficient for a confidence level of 1 - 1/h.

For example, if h = 100, then

$$1/h = .01,$$
$$1 - 1/h = 0.99, \text{ and}$$
$$n > 460.5.$$

In other words, if we perform at least 461 tests without failure, we can be 99% sure that the failure rate is below .01.

Levy's Law

Only God can make a random selection.

The major difficulty with statistical testing is the selection of the random inputs. The inputs must be selected according to the *operational distribution* of input values. The operational distribution is the frequency with which values are selected during actual program use. The problem is that the operational distribution is usually not known. It is rarely uniform. Some input values are much more likely to be used than others. If test inputs are chosen according to some other distribution, then the statistical results can be greatly biased. Often the only way to select input values according to the operational distribution is to let the program be tested in the field by the intended users.

All of the testing methods discussed here are examples of *functional testing* methods. Functional tests verify that the program computes the correct functions. This is by no means the end of testing. In addition, performance tests check whether the software meets its non-functional specifications such as timing and storage requirements. Background tests execute programs under realistic background loads in order to reveal time-dependent faults. Stress tests intentionally try to crash a program in order to find its limits (the maximum number of users the program can handle, the maximum number of transactions, the maximum size of files, etc). Security tests check that security mechanisms cannot be breached.

Howe's Law

Everyone has a scheme that will not work.

This discussion points out how difficult testing can be. For this reason, and more emphasis is now placed on methods for eliminating errors in requirements and design before any code is written. In software development, however, all errors are human errors. Therefore, it is unrealistic to expect that we can completely eliminate all coding errors by using better methods, better tools, or better programmers. We will continue to need testing and other validation methods for detecting and correcting our mistakes.

NEXT TIME: Alternatives to testing for software validation.

References

1. Beiman, J., and J. Schultz, "Estimating the Number of Test Cases Required to Satisfy the All-du-paths Testing Criterion", *Proceedings of the ACM SIGSOFT '89 Third Symposium on Testing Analysis, and Verification*, Dec. 1989, pp. 179 - 186.

2. Beizer, Boris, *Software System Testing and Quality Assurance*, Van Nostrand Reinhold, New York, 1984 (covers all aspects of quality assurance throughout the software development life cycle).

3. Bloch, Arthur, *Murphy's Law and Other Reasons Why Things Go Wrong*, Price, Stern, and Sloan, 1977 (the source of the boxed quotes).

4. Fairley, Richard E., *Software Engineering Concepts*, McGraw¬Hill, New York, 1985 (a good introductory textbook on software engineering).

5. Halstead, M., *Elements of Software Science*, Elsevier, New York, 1977.

6. Howden, William E., *Functional Program Testing and Analysis*, McGraw-Hill, New York, 1987 (a theoretical treatment of testing and analysis).

7. Woodward, M. R., D. Hedley, and M. A. Hennel, "Experience with Path Analysis and Testing of Programs", *IEEE Transactions on Software Engineering*, Vol. 6, 3, May 1980.

BIO

Virginia Stover is currently an Associate Professor of Mathematics and Computer Science at the University of San Diego. She received a PhD in mathematics in 1981 and an MS in Computer Science in 1986, both from the University of California, San Diego. Current research interests include software engineering and expert systems.

PLOTTING SOFTWARE PACKAGES

Paul Elliot

While searching for the ideal PC scientific plotting software package, I have collected the comments below. We may have a "shootout" between some of these soon, at which time we would inform you of the results. If any readers have tried some of these, please consider sending in comments. Most of the following information is gleaned from conversations with users over the last couple of years. I think most of the comments made are up to date and accurate but they are far from complete. GraphicC and Harvard Graphics are the only packages I have personally used so far so this is by no means a comprehensive comparison or endorsement and I have not verified the accuracy of all the comments made. The following are not listed in any particular order.

The first 8 are designed for scientific use. They will produce a wide variety of scientific plots including 3D and contour plots unless otherwise stated.

1. Microplots ($299, free demo disk) : Scientific Concepts Inc. 2359 Windy Hill Rd., Suite 2Ol-J, Marietta, GA 30067. (404)438-4181. Advantages: Will accept a wide variety of input data formats and very large input data files. will plot multiple plots per page. Disadvantages: Will not plot directly to dot matrix printer unless passing data through a word processor.

2. EasyPlot ($249, free demo disk) : Spiral Software, 6 Perry St., Suite 2, Brookline, MA 02146. (617)739-1511. Advantages: Easy to plot. Fast. Can also do some math functions on data like curve fitting and FFT.

3. Graphtool ($495, $15 for demo disk): 3-D Visions, 412 S. Pacific Coast Hwy, Suite 201, Redondo Beach, CA 90277 (213)540-3492. This package used to cost much more. I do not know anyone who has tried it.

4. GraphicC ($395): Scientific Endeavors Corporation, 508 N. Kentucky St., Kingston, TN 37763. (615)376-4146. Advantages: Good quality graphics, lots of features. Can be programmed to do 3D plots. Site license available. Disadvantages: Consists of sub-routines which then require a good deal of programming to create plotting programs. Requires C compiler.

5. Tech-Graph-Pad ($395, free demo) : Binary Engineering, 400 Fifth Ave. , Waltham, MA 02154. (617)290-5900. I only know what is in their direct mail ad, which quotes many positive reviews from magazines such as PC magazine which claim it is very easy to use. Disadvantage: No 3D plots.

6. Datatap Graph ($299): Mihalisin Assoc., 600 Honey Run Rd., Ambler, PA 19002. (215)646-3814. I have only seen their ad, "which shows a variety of types of 2D but no 3D plots.

7. Asyst ($500+): MacMillan Publishing Co. Advantages: will do symbolic math computations (like MathCAD) as well as plotting. Disadvantages: Difficult to learn. Better suited to plotting with real-time data aquisition than to plotting data files. Poor file interaction.

8. F-Curve II ($60): LEDS Publishing Co., Research Triangle Park, NC (919)477-3690. I was unable to reach company and do not know anything about package.

These last three packages are designed mainly for business use. They can make 2D line plots.

9. Graph-in-the-Box ($69) : Widely available. Advantages: Low cost. Easy to use. Disadvantages: No 3D or contour plotting capability. X axis increments between data points must be uniform.

10. Harvard Graphics ($299) : widely available. Advantages: Easy to use. Very good quality graphics. Also makes very large text for viewgraphs. Disadvantages: Line plots limited to 240 points per curve. All the curves must be in different columns in one data file; cannot also input different curves from different data files.

11. LOTUS 123 ($319): widely available. Advantages: Incorporates spreadsheet features for data manipulation, rearranging columns, sort, merge, calculating means and standard deviations, etc. Disadvantages: Title lettering is thin. If not familiar with Lotus it takes longer to learn since it is more than Just a plotting package.

ADVERTISEMENTS

ANNOUNCING

A SPECIAL ACES PUBLICATION

"THE ACES COLLECTION OF CANONICAL PROBLEMS-SET 1"

AVAILABLE STARTING 19 MARCH 1990

GUEST EDITOR

HAROLD SABBAGH

MEMBER COST: US $9.00 INTERNATIONAL $12.00

NON-MEMBER: US $15.00 INTERNATIONAL $20.00

PICK UP A COPY AT THE ACES CONFERENCE IN MONTEREY, 19-22 MARCH

AND SAVE THE POSTAGE

(PRICE AT CONFERENCE: $7.50)