APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

Vol. 7 No. 2 July 1992

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EDITOR'S COMMENTS

The interesting variety of articles in this issue is evident from the table of contents. Follow-up articles by Chalmers Butler, Randy Jost, Dusan Zrnic and Kultegin Aydin will also be forthcoming in the November issue. The scope of the "Perspectives" column has been broadened to include contributions from a wider range of people including government agencies, and it will still feature contributions from ACES founders, editors, and committee members. Thanks to Editors Dave Stein and Ray Perez for their work in soliciting "Perspectives" articles. Check the assortment of important announcements at the end of the Newsletter.

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ACES NEWSLETTER COPY INFORMATION

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

Send copy to Paul Elliot at the above address 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 Macintosh disks. On IBM disks we can also read Wordperfect and Wordstar files. If any software other than Microsoft Word has been used on Macintosh Disks, contact the Secretary BEFORE submitting a diskette. If it is not possible to send a Macintosh disk then the hardcopy should be in Courier font only for scanning purposes.

NEWSLETTER ARTICLES AND VOLUNTEERS WELCOME

The ACES Newsletter is always looking for articles, letters, and short communications of interest to ACES members. All individuals are encouraged to write, suggest, or solicit articles either on a one-time or continuing basis. Please contact a Newsletter Editor.

AUTHORSHIP AND BERNE COPYRIGHT CONVENTION

OFFICER'S REPORTS

PRESIDENT'S REPORT

My first executive decision was made at the Symposium Banquet in Monterey. The head waitress was looking for Stan Kubina, our outgoing President, but couldn't find him, and asked if I could help. I asked her about the problem, and she replied that the banquet was set for a half-hour earlier than what the program listed, and if we didn't start soon, the cook would burn the meal. I immediately announced to the gathering that dinner was served (and this before I officially replaced Stan, mind you).

Now that I have succeeded Stan, I take great pleasure in thanking him, the Board of Directors, and all the little people (and they know who they are) for faithfully supporting and promoting the Society. Things have been a little tough in our industry lately, but theSociety weathered the storm and put on a very nice symposium. I especially thank Pat Foster for her excellent direction of the symposium.

These are exciting times for ACES, and the potential for outreach is great. The ACES/TEAM international workshops in code validation are proceeding well, with TEAM desiring to continue the relationship. COMPUMAG and CEFC, two conferences on computational electromagnetics, have expressed interest in joining our conference to theirs (CEFC'94 is in Grenoble, France, but after the skiing season!). COMPUMAG and CEFC both publish their conference proceedings in the IEEE Magnetics Society Transactions. The Japan Society of Applied Electromagnetics in Materials is interested in cooperating with ACES. This cooperation could take the form of exchanging advertisements, offering a reduced subscription rate to ACES members for the International Journal of Applied Electromagnetics in Materials (6500 yen instead of 19,500 yen for four annual issues), jointly sponsored workshops, and an exchange of newsletterarticles. A number of researchers from Europe and Asia attended our symposium for the first time.

There are other manifestations of this international outreach: Tony Fleming has organized an ACES International Workshop in Australia, 14 August 1992, which TEAM has agreed to officially sponsor, as well; Pat Foster and David Lizius have organized the UK Chapter of ACES; Prof. Luis M. Correia, of the Technical University of Lisbon, has agreed to serve as ACES representative in Portugal, and Duncan Baker, of the University of Pretoria, has agreed to serve as ACES representative in South Africa.

This geographical distribution is marvelous, because it does two things: it indicates that computational electromagnetics is a very real discipline, with an international constituency that perceives us to be a focal organization; and it gives us a strength and vitality that we wouldn't have if we remained a rather local organization. I am using the word "local" in two senses: geographical and cultural. ACES was organized to meet a perceived need -- to fill a vacuum on computational electromagneticsin the US. Most of the early organizers were probably most interested in radiation and scattering problems, and perhaps most members are still similarly inclined. The fact is, however, that a great deal of computational electromagnetics being done around the world involves low-frequency matters (or, to be more precise, industrial matters). Practitioners in our national labs are being forced to turn their attention from defense-related matters to commercial and industrial matters, as well. ACES must be similarly motivated to broaden its perspectives and perceptions of what computational electromagnetics is. As we do this we will be better able to serve our national and international members, thereby creating a more robust, independent, organization.

This can be done in several ways, perhaps the most important being to return to our roots and concentrate on developing, distributing, and validating codes and computational techniques, and doing this across the spectrum of frequencies, applications, and nations. Our Software Exchange Committee, under Frank Walker, has some excellent plans that deal with the distribution of software, and the Software Performance Standards Committee, which is lead by Andy Peterson, is developing some new canonical problems and protocols for validating software. This is already becoming an international activity, with several people from Europe proposing problems. I am especially excited about this, because I believe that it fills a significant technical void. As activities in this area and others expand, ACES will grow in technical stature.

None of this, of course, can happen without the support of the little people, and we know who we are. If you wish to participate in any of these activities, or wish to propose others, please let me know.

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MINUTES OF THE
ANNUAL BUSINESS MEETING
OF THE
APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

The annual business meeting of the Applied Computational Electromagnetics Society, Inc. convened in room 122 Ingersoll Hall at the Naval Postgraduate School at 7:35 AM PST on 17 March 1992.

President Stan Kubina presided.

REPORT OF ELECTIONS: The Elections Committee reported that Richard W. Adler, James K. Breakall and Frank E. Walker were elected to the Board of Directors for a three year term.

CORPORATE STATUS: The secretary announced that the California Non-Profit application was filed last year and a temporary non-profit status is in place. Permanent California status depends upon the IRS (Federal) status being granted. The Federal Non-Profit process has been launched and final details are now being covered by the accountants. A decision from the IRS is due by Fall '92. We paid $0 US taxes last year.

FINANCIAL STATUS: An accountant's report to the Board of Directors was reviewed. (A copy follows these minutes.) The Treasurer's report was printed in the March Newsletter. The Financial Committee's 5-Year Plan shows a positive cash flow can be obtained by a modest increase of dues of $5/year as opposed to the $10/year that was anticipated. The Board of Directors approved a new membership fee structure for surface mail delivery of ACES publications for non-US members, which holds down the cost of membership. It still allows for optional Airmail delivery to be obtained at additional cost. (The new membership fees are listed in this newsletter)

President Kubina noted that the annual conference is very important and is the lifeblood of the society. It provides an excellent opportunity to exchange information on a one-on-one basis.

NEEDS AND GOALS: President Kubina noted that ACES must continue to provide SERVICES to members. Most of the services are provided by the members themselves, for example, as they serve on committees. ACES is cooperating with other societies and groups such as TEAM, CEFC and COMPUMAG. We welcome any suggestions from the membership.

The meeting was adjourned at 7:58 AM.

Respectfully submitted
Richard W. Adler, Secretary

Kasavan, Pope
& McGilloway
CERTIFIED PUBLIC ACCOUNTANTS

To the Board of Directors
Applied Computational Electromagnetics Society
Monterey, CA

We have compiled the accompanying statement of assets, liabilities and equity - income tax basis of Applied Computational Electromagnetics Society (a California corporation) as of December 31, 1991, and the related statement of revenues and expenses - income tax basis, for the year then ended, in accordance with standards established by the American Institute of Certified Public Accountants. The financial statements have been prepared on the accounting basis used by the Company for income tax purposes, which is a comprehensive basis of accounting other than generally accepted accounting principles.

A compilation is limited to presenting in the form of financial statements information that is the representation of management. We have not audited or reviewed the accompanying financial statements, and accordingly, do not express an opinion or any other form of assurance on them.

Management has elected to omit substantially all of the disclosures ordinarily included in financial statements. If the omitted disclosures were included in the financial statements, they might influence the user's conclusions about the Company's assets, liabilities, equity, revenues and expenses. Accordingly, these financial statements are not designed for those who are not informed about such matters.

Kasavan, Pope & McGilloway
Monterey, CA
March 11, 1992

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APPLIED COMPUTATIONAL ELECTROMAGNETICS
Statement of Assets, Liabilities and Equity - Income Tax Basis
December 31, 1991

ASSETS

Cash	$	33,443
Property, Plant and Equipment		
Furniture and Equipment		5,203
Less: Accumulated Depreciation		(2,395)
Total Property, Plant and Equipment		2,808
TOTAL ASSETS	$	36,251

LIABILITIES AND EQUITY

Stockholder's Equity		
Retained Earnings - Beginning	$	40,494
Current Year Net Income/(Loss)		(4,243)
TOTAL LIABILITIES AND EQUITY	$	36,251

See accountant's compilation report

APPLIED COMPUTATIONAL ELECTROMAGNETICS
Statement of Revenues and Expenses - Income Tax Basis
For the year ended December 31, 1991

		%
Revenue		
Conference	$ 38,485	50.3
Publications	2,846	3.7
Software	3,773	4.9
Membership Dues	23,903	31.3
Short Course	7,530	9.8
Less: Refunds	(90)	(0.1)
Total Revenue	76,447	100.0
Direct Expenses		
Conference - See Schedule 1	22,759	29.8
Publications - See Schedule 2	23,217	30.4
Software - See Schedule 3	568	0.7
Short Course - See Schedule 4	5,140	6.7
Total Direct Expenses	51,684	67.6
General & Administrative		
Bank Charges	160	0.2
CAEME Project Support	6,000	7.8
Taxes	1,880	2.5
Secretary	4,844	6.3
Office	3,151	4.1
Professional Fees	682	0.9
Postage	11,782	15.4
Telephone	2,044	2.7
Depreciation	1,549	2.0
Total General & Administrative	32,092	42.0
Total Expenses	83,776	109.6
Income/(Loss) From Operations	(7,329)	(9.6)
Other Income/(Expense)		
Interest Income	2,351	3.1
Other Income	895	1.2
Miscellaneouse Expense	(160)	(0.2)
Total Other Income/(Expense)	3,086	4.0
Net Income	$ (4,243)	(5.6)

See accountant's compilation report

APPLIED COMPUTATIONAL ELECTROMAGNETICS
Supporting schedule of Direct Expenses - Conference
For the year ended December 31, 1991

		%
Printing	$ 10,993	14.4
Proceedings	800	1.0
Refreshments	2,126	2.8
Secretary	3,588	4.7
Supplies	1,863	2.4
Banquet	1,360	1.8
Sponsored Attendees	1,999	2.6
Vendor Expense	30	
Total	$ 22,759	29.8

See accountant's report.
Schedule 1

APPLIED COMPUTATIONAL ELECTROMAGNETICS
Supporting schedule of Direct Expenses - Publications
For the year ended December 31, 1991

		%
Flyer Advertisement	$ 357	0.5
Flyer Secretary	631	0.8
Flyer Printing	4,263	5.6
Journal Printing	8,805	11.5
Journal/Newsletter Secretary	2,695	3.5
Newsletter Printing	6,466	8.5
Total	$ 23,217	30.4

See accountant's report.
Schedule 2

APPLIED COMPUTATIONAL ELECTROMAGNETICS
Supporting schedule of Direct Expenses - Software
For the year ended December 31, 1991

		%
Needs Printing	$ 86	0.1
Needs Secretary	482	0.6
Total	$ 568	0.7

See accountant's report.
Schedule 3

APPLIED COMPUTATIONAL ELECTROMAGNETICS
Supporting schedule of Direct Expenses - Short Course
For the year ended December 31, 1991

		%
Instructor	$ 3,752	4.9
Supplies	1,388	1.8
Total	$ 5,140	6.7

See accountant's report.
Schedule 4

COMMITTEE REPORTS

ACES EDITORIAL BOARD

New ways of thinking are the key to meeting present challenges which now face the ACES Editorial Board and the ACES membership.

One challenge is to maintain simultaneously the ACES Journal special (thematic) issue program and "rapid turnaround" for regular issue contributors. Special issues, at one time the primary means to make our existence known (and thereby attract papers for our regular issues), remain indispensable in our efforts to serve various computational electromagnetics communities -- an imperative if we are to promote an exchange of knowledge across disciplinary boundaries. This "cross -pollination", in turn, is essential to achieving two ACES objectives: (1) minimizing the need to "re-invent the wheel" and (2) advancing the state-of-the-art (especially beyond the level achievable from single-community inbreeding). At the same time, our average four-month turnaround (from initial submission to publication) has made the ACES Journal exceptionally attractive to authors during times when typical turnarounds associated with the established journals ranged from one to two years. Had the ACES Journal not offered rapid turnaround, its survival might have been imperiled.

However, under the present limitation of two ACES Journal issues per year and the constraint that a special issue replaces a regular issue, publication of a special issue inhibits our rapid-turnaround capability -- although fortunately, no ACES Journal author has yet experienced an excessive wait for his or her acceptable paper to appear in print. (Furthermore, even if we were to publish only regular issues henceforth, the two-issues-per-year constraint, in conjunction with the rapid-turnaround requirement, would render impractical any effort to build a small backlog of accepted papers as "insurance" against a subsequent shortfall of papers. Again, while we cannot afford complacency, we are fortunate not to be experiencing a shortfall. In fact, our very success in attracting more quality papers mandates an increase in frequency of publication).

For these reasons, tri-annual (three issues/year) capability, as we already have for the ACES Newsletter, is needed for the ACES Journal. At first thought, an increase in membership dues is the obvious way to acquire the necessary financial resources. Yet, in some parts of the world in which ACES members reside, the salary scales differ significantly from those in the United States, and as a result, membership in ACES is already expensive (especially when the overseas optional postal airmail surcharge is considered). An innovative solution, responsive to ACES members of all nationalities, is needed.

Another challenge is to develop standards of publication for "non-mainstream" areas such as parallel processing, hardware issues, input/output innovations, artificial intelligence, and computational electromagnetics education. Determination of whether a paper is "scholarly" (and appropriate for a refereed journal) or not becomes less straight forward -- notwithstanding our thorough peer-review process. Standards of publication for these areas will evolve from our peer-review process, but these standards are not readily definable today.

A third challenge is to assess the originality of papers submitted for publication (or alternatively, to re-define the criteria which a scholarly journal must satisfy). Even prestigious, established physics journals and electrical engineering journals have published papers which, although believed by the authors and editors to be original, were actually recapitulations of other papers published decades ago, sometimes but not always in obscure journals. In the absence of an on-line abstract reference system (which is beyond our present resources and which is not used even by the established journals), we must rely on our Editors and referees to judge originality. Unfortunately, even the greatest luminaries cannot be expected to be familiar with all papers previously published on a given subject, and therefore, not all recapitulations will be identified. As a consequence, technical journals continue to be victims of -- and further contributors to -- the "knowledge explosion".

We must meet the aforementioned challenges in unfavorable economic conditions. Research funding constraints may impact the number of technical papers written. In addition, technical staff downsizings in corporations will not always be matched by workload downsizings, and this will impact the availability of volunteer labor -- the lifeblood of professional societies such as ACES.

Nonetheless, we should be encouraged by our success in meeting other challenges, notable among which is publishing papers which are both scholarly and practical. The traditional scholarly paper often fails to address real-world problems (and this failure was a primary motivation for the founding of ACES). This type of paper is generally of limited interest among readers. Conversely, many applications-oriented papers are not scholarly and are therefore appropriate more for magazines than for refereed journals. In the ACES Journal, the dichotomy between the traditional scholarly paper and the applications-oriented paper does not manifest, though our work is not yet finished.

In preparing for tomorrow, we do not know all of the answers, but we have the Editors and members who will find the answers.

David E. Stein
Editor-in-Chief

ACES SOFTWARE PERFORMANCE STANDARDS COMMITTEE

The activities of the Committee currently center around the continued participation in workshops aimed at building a collection of canonical problems for use as benchmarks for software validation. An ACES/APS workshop on benchmark problems will be held on July 25, 1992 following the IEEE-APS International Symposium in Chicago. In addition, a TEAM (Testing Electromagnetics Analysis Methods) workshop will be held at the Fifth Biennial Conference on Electromagnetic Field Computation (Harvey Mudd College, August 6-7, 1992).

Because of the wide range of application areas, "working groups" have been established to narrow the scope of the task of collecting canonical problems. In the past, working groups were limited to the application areas *Wires, Surfaces & Penetrable Objects, and Time Domain*. During the upcoming workshops, we hope to expand the number of working groups in order to encompass a variety of application areas.

The Committee's activities are expected to proceed as follows: Each working group shall identify a short list of 3-5 precisely defined problems. These will be proposed to the EM modeling community, which responds by attempting to solve them and routing their solutions back to the working group. (The solutions may be based on measurement, numerical modeling, analytical approximation, etc). After a suitable time interval a particular working group may decide that a problem is "solved", archive the solution in the database, and remove it from the list of active problems. (The issue of what constitutes a "solved" problem is one that we will have to deal with over time). In this manner, we will gradually build a database of solved problems. Regular workshops will provide a forum for working groups to meet and discuss their business, including a review of new proposed solutions, decisions as to whether a problem is considered solved or not, and the identification of new canonical problems to replace those considered solved. Regular publications will document the progress and make the results available to the research and user communities.

Within this organizational framework, the key unit is the working group. Since all the working groups conduct business simultaneously at workshops, it will probably be necessary for each participant to be affiliated primarily with one group. Each working group is free to decide what canonical problems to propose and whether or not a problem is solved and should be added to the database. It is anticipated that there may be a large "turn over" of participants from one workshop to the next, and therefore some means (detailed reports?) will be necessary to ensure continuity of activities from one workshop to the next.

The primary goal for the upcoming activity at Chicago is to create new working group designations and to have each working group identify a small number of canonical problems in their respective areas. These problems will be publicized in an upcoming Newsletter.

Andrew F. Peterson

PERSPECTIVES ON ACES AND COMPUTATIONAL ELECTROMAGNETICS

The ACES Newsletter continues this series of "Perspectives" articles to provide a forum for discussion of present and future needs in computational electromagnetics, areas of challenge, and potential electromagnetic solutions. As a result of this discourse, it is hoped that electromagnetics related problems and requirements can converge with prospective solutions. Perspectives from a wide range of applications and work settings will be represented, including international scientific institutions, educational institutions, government labs and agencies, and and industry. This issue features "Perspectives" articles on "Polarimetric Signatures of Precipitation" and "What Ever Happened to Unified Field Theory". A follow-up article on the first article will also be provided in the next ACES Newsletter.

POLARIMETRIC SIGNATURES OF PRECIPITATION

Dusan S. Zrnic[1], and Kultegin Aydin[2]

Introduction

At the present time weather radar polarimetry is at a stage of development that Doppler weather radar (Doviak and Zrnic, 1984) was in the early seventies. Significant strides have been made in understanding echoes from certain hydrometeor types (e.g., raindrops and hailstones) and there is enough evidence to suggest that improved rain estimates will be possible (Atlas, 1990). Yet, much remains to be done before the full potential of polarization radars can be realized. The purpose of this note is to provide a qualitative status report on weather radar polarimetry and the role that electromagnetic modeling plays from the particular perspective of remote sensing. To that end we list here the main reasons why weather researchers are involved in radar polarimetry.

1) Remote measurements and discrimination of precipitation types are important for understanding microphysical processes in all storms. Although this research was initially driven by scientific curiosity it now has proven to have practical utility. For example, any serious attempt at weather modification could be verified with polarization measurements.

2) Use of polarization to estimate the amount and type of precipitation that falls on the ground is a very practical goal that may be realized with future enhancements on the Next Generation Weather Radars (the new Doppler radars which bear a designation WSR-88D).

3) Polarization on spaceborne radars may be used to discriminate between liquid and frozen precipitation and that could provide better inputs, especially latent heat, to measurements of global energy budgets.

Polarization Measurands

Some bulk properties of hydrometeors can be estimated if the probability density function (pdf) of the weather echo signals is known. It is not practical to obtain this pdf but it is relatively simple to obtain second order moments. First order moments are zero, and that is the reason that the scattering matrix has a significantly different role in weather radar. Namely, the second order moments of the pdf are proportional to various correlations between scattering matrix terms.

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These second order moments we define as fundamental measurands that a polarimetric radar provides. Some of these are well known but others are not. We consider here only two linear orthogonal polarizations but the general conclusions are also valid for two elliptical orthogonal polarizations. There are at most nine measurands that contain fundamental information on polarization properties of hydrometeors. They are: two reflectivity factors Z_h, Z_v, (one for horizontal, the other for vertical polarization), one reflectivity factor Z_{hv} obtained by transmitting vertical polarization and receiving horizontal (because of reciprocity $Z_{hv} = Z_{vh}$), three correlation coefficients COR(Z_h, Z_v), COR (Z_h, Z_{hv}), COR (Z_v, Z_{hv}), and three differential phases that are byproducts of computations of the three correlation coefficients. Signal processing techniques to retrieve all the measurands simultaneously with the Doppler parameters have been established and tested successfully.

Polarimetric signatures

Determination of polarimetric signatures requires the design of a multiparameter decision rule by which one attempts to associate a specific population of hydrometeors with a domain of values of a subset of polarimetric variables. Briefly, a partition of the nine dimensional space of polarimetric variables is sought so that a correspondence between hydrometeors and the partitions can be established. This appears to be a formidable task but it can be reduced to a manageable algorithm if only a few (two or three) polarimetric variables carry the critical discriminating information. For example, hail and rain can be separated because their reflectivity and differential reflectivity [$10\log(Z_h/Z_v)$] data show distinct groupings. Also, discrimination is enhanced with the help of auxiliary data such as beam height above ground and temperature. Even when these simplifications are possible there is one more aspect that adds complexity, namely our desire to obtain quantitative measurements.

Both qualitative and quantitative measurements are extremely difficult to verify. Nevertheless three approaches are utilized. In situ measurements on the ground or with aircraft provide values at a point or along a line in very limited regions of storms. Self consistency among polarimetric measurands adds some confidence to interpretations. Modeling provides a theoretical framework to which the measurements are being tied and will be discussed in a future newsletter.

References

Atlas, D. ed., 1990: "Radar in Meteorology." Am. Meteor. Soc. Boston, MA.

Doviak, R. J. and D. S. Zrni , 1984: "Doppler Radar and Weather Observations" Academic Press, Inc.

Sachidananda, M., and D. S. Zrni , 1988: Efficient processing of alternately polarized radar signals. *J. Atmos. Oceanic Technol.*, 4, 1310-1318.

BIO

Dusan S. Zrnic (born in Belgrade, Yugoslavia, Dipl. Ing. degree in EE University of Belgrade 1965, MS in EE 1986 and PhD EE in 1989 University of Illinois, Urbana) is Chief of the Doppler Radar and Remote Sensing Research group at the National Severe Storms Laboratory (NSSL), and Adjunct Professor of Electrical Engineering and Meteorology at the University of Oklahoma in Norman. During the last fifteen years the thrust of his effort was in improvements of weather radar signal processing, advancements of polarimetric measurements and their interpretation, and development of algorithms for NEXRAD. Since 1976 he has been a member of URSI Commissions C and F; he is a member of the AMS and a fellow of IEEE. He has published extensively in scientific and engineering journals and is associate editor of the Journal of Atmospheric and Oceanic Technology. Twice he has been awarded the Best Research Paper Award by the Environmental Research Laboratories. Dusan is a co-recipient of the IEEE 1988 Harry Diamond Memorial Award for contributions to and applications of weather radar science.

BIO

Kultegin Aydin was born in Sandikli, Turkey. He received the Ph.D degree in electrical engineering from the Middle East Technical University (METU), Ankara, Turkey, in 1979. From 1979 to 1981, he was on the faculty at METU. He later joined the Atmospheric Sciences Program and the Department of Electrical Engineering at the Ohio State University, Columbus, as a Post-doctoral Research and continued working there as a Senior Research Associate until 1985. Since 1985, he has been on the faculty in the Department of Electrical and Computer Engineering and a member of the Communications and Space Sciences Laboratory at the Pennsylvania State University, University Park. His research interests include radar remote sensing applied to meteorological phenomena, electromagnetic scattering, and propagation. Dr. Aydin is a member of the Institute of Electrical and Electronics Engineers.

WHATEVER HAPPENED TO UNIFIED FIELD THEORY?

Peter S. Excell
University of Bradford, UK.

Much is heard nowadays from physicists attempting to find a grand unified field theory which will link all the forces of nature into a single structure. Consideration of where this exercise started, however, suggests that their efforts may be in vain since the users of the fields do not seem to be particularly interested in exploiting unified forms.

Although it might be augued that unification efforts started with attempts to link gravity to electric and magnetic fields, the first real breakthrough came with Einstein's special theory of relativity which, *inter alia*, showed that the magnetic field could be explained as a relativistic modification of the effective field, or of the action-at-a-distance between charged particles. Indeed, Einstein's first paper on relativity was entitled "On the Motion of Charged Bodies" and the theory was derived from consideration of problems implicit in Maxwell's equation, although these aspects are nowadays almost forgotten by non-specialists who imagine that the theory is all to do with $E = mc^2$ and with twin brothers who age at different rates because one has taken a trip in a rocket ship!

Even the most basic undergraduate electromagnetics course has to attempt to teach the meaning and manipulation of no less than six fields (two field strengths, two flux densities, and two potentials) which are all manifestations of the electromagnetic field and there is scope for the incorporation of several other field concepts to the extent that there is a danger of encouraging an appetite for "collecting". Users develop likes and dislikes among the fields, for instance, at least one book by an eminent author includes a lengthy diatribe against the magnetic vector potential although ultimately conceding that users would have to live with it. At one time, this writer took the same view, but experience has shown the MVP to be one of the most useful concepts and one that is really not so difficult to understand if it is seen as the dual of the scalar potential. On the other hand, considerable difficulty has recently been experienced in explaining the meaning, and justifying the existence, of the electric flux density!

All this begs the question of whether a radical new approach could improve understanding and make the subject more interesting and acceptable to today's students. Supposing that everything were to be treated in terms of a relativistically-modified electric field, there is no doubt that the mathematical treatments would be far more complex than under the existing system (this is the reason why the other field concepts were invented), however, the increasing power and significance of computer algebra software packages might just circumvent this objection. There is undoubtedly a problem in that, in principle the modelling of currents, dielectrics and magnetic materials would have to be treated as vast and intractable many-body interaction problems (at least under the action-at-a-distance viewpoint) but there should be ways of handling these by lumping them into manageable clusters. Aside from the most significant objection that a huge amount of effort has been invested in the existing theoretical structure and that to discard it would be an impractical waste (bear in mind that, unlike the phlogiston or ether theories, it is not actually *wrong*), the chief problem that may be forseen is that the unified electric field would come to be seen as having two components, a static component and a motional component, the latter simply being the magnetic field under another name! Nonetheless, it would appear that an exploration along these lines would be worthwhile, the only residual problem being that no organisation appears willing to fund it!

BIO

Peter Excell is Reader in Applied Electromagnetics in the Department of Electrical Engineering at the University of Bradford (West Yorkshire, England). His principal research interests are in computational electromagnetics, radio-frequency superconducting devices, and compact ranges. He is a founding member of ACES and serves on the ACES Journal Editorial Board.

CONFERENCE REPORT: - INTERNATIONAL CONFERENCE ON COMPUTATION IN ELECTROMAGNETICS - CEM'91

Brian A. Austin
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When EM computer modelers get together to discuss their trade it very soon becomes obvious that the community contains at least two distinct groupings. These are most easily recognizable when one considers the operating frequency of the end-product of their computational efforts. There are those who address themselves to the low frequency end of the spectrum and whose applications involve machines, magnets and devices which are very amenable to computational analysis using Finite Element and other allied approaches. Then there are those whose interests involve communications-related products in the main at frequencies of megahertz and above with computer codes using the method of moments, the geometrical theory of diffraction and so on. Unfortunately the two groups don't often get together to exchange ideas and swap experiences. In many instances they are using similar techniques but under different names to solve problems which superficially have nothing in common, but often after some probing present many common areas.

In an attempt to provide a forum at which these two groups,and others, maybe in a twilight world in between, could get together, the IEE held a conference in London from 25-27 November 1991. The intention was to try and encourage some cross-fertilization of ideas between researchers who in their normal, day-to-day lives, would be unlikely to meet those doing similar things but usually well separated in frequency and hence in application. As it turned out, we seemed to have tapped a rich source of interest because the call for papers produced an almost overwhelming response from researchers worldwide. The original idea of a two-day, single session affair soon became three days with parallel sessions. The process of reviewing abstracts was arduous, but highly encouraging, given their high quality in the main. Eventually a programme was put together in which every effort was made to adhere to our central theme of bringing these disparate groups together. The split was made between techniques rather than applications. This meant that there were sessions entitled Finite Elements (Low Frequency) and Finite Elements (High Frequency), Moment Methods (three sessions), TLM (two sessions), Finite Difference, Modal Expansion and Mode Matching, Ray Methods and Boundary and Integral Methods. In many cases they contained papers on applications far removed from each other but which used similar analytical tools. This approach, judging by the comments received, seemed to work.

Because ultimately computer hardware and software formed the focal point of so many papers it was felt that a display of software particularly would complement the sessions and provide an opportunity for code developers and vendors to show their wares. Again this attracted a good balance across the frequency spectrum and was favourably received by most delegates. As always, there are some papers better suited to a poster display than formal presentation in a session and many authors actually requested they be allocated to the poster display. The posters were rotated over the three days and so allowed a considerable range and variety of material to be displayed.

Attendance was good. In fact it was better than expected, given the prevailing economic climate. All told there were 190 delegates from 22 countries.

One negative aspect which unfortunately now seems to be a feature of many international conferences was the non-attendance of some authors whose papers had been accepted and were included in the bound proceedings. Whereas one recognizes that researches from some countries are never certain they will eventually be able to attend, it saddened and surprised everyone at CEM'91 when some of the non-attendees where from prestigious organisations in countries not so afflicted.

There may well be a case to be made for instituting of "block list" of such defaulters.

The conference took place at the imposing headquarters of the IEE on the bank of the Thames at Savoy Place in London. In retrospect, one felt that the great city with all its attractions is probably not the ideal venue for an event where interaction between delegates is a major feature. How do you compete after hours with the attractions offered in a city like London? We didn't try - other than by hosting a cocktail party on one evening which was very successful and did achieve the objective, judging by the level of animated conversations. The next one - and we believe there is a need for a follow-on event - should probably move away from the city and onto a campus where the distractions are less and the opportunity for informal discussions are always present.

The proceedings of this conference are available from the IEE as Conference Publication Number 350.

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A PARADOX IN COMPUTING ELECTRIC FIELD FROM CURRENTS

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It is well known that one can compute the electric field due to electric current and charge from the magnetic vector potential and the electric scalar potential or from the vector potential alone. When doing so one must be careful to interpret the results properly. This is particularly important in computational techniques involving the so-called electric field integral equation (*EFIE*) and its numerical solution. If effective numerical methods are to be developed for solving the *EFIE*, one must have a precise understanding of the full meaning of the electric field integral equation, either in its form based upon electric field expressed in terms of mixed potentials, i.e., in terms of both vector potential and scalar potential, or in its form based upon electric field expresed in terms of the vector potential alone. To illustrate this point, the electric field due a current distribution is computed both ways below to obtain results that are different.

The interested reader is invited to inspect the dual derivations below for expressions for electric field and explain why the results are different. If one is not interested in the simple mathematical steps leading to the results, he or she may simply choose to read the first few sentences below in which the current is described and then skip to the two different results for electric field given in Eqs. (14) and (15). Many readers will immediately understand why (14) and (15) are different. If you do not and if you are interested in developing your own numerical methods for solving the EFIE, or in critically reviewing those created by others, then it behooves you to investigate this paradox further. Why (14) and (15) are different will be addressed in the next issue (November, 1992) of the **ACES NEWSLETTER**. A full discussion of the paradox will be presented.

We consider a simple case of a $z-$directed surface current of density $\mathbf{J} = J(z)\hat{\mathbf{z}}$ which resides on a (imaginary) cylinder of radius a and length $2h$. For convenience, let the cylinder axis coincide with the z axis of a cylindrical coordinate system and let the center of the cylinder be at the coordinate origin, which means that the upper and lower ends of the cylinder are at $z = h$ and $z = -h$, respectively. This current distribution is of harmonic time variation $e^{j\omega t}$, is circumferentially invariant, i.e., independent of ϕ, and is embedded in a homogeneous space of infinite extent characterized by (μ, ϵ). We wish to determine the $z-$directed electric field on the z axis by two methods. One method is based on the use of the fundamental "mixed potential" expression

$$\mathbf{E} = -j\omega\mathbf{A} - \nabla\Phi \tag{1}$$

while the other is based on the following expression involving only the vector potential:

$$\mathbf{E} = -j\frac{\omega}{k^2}\left(k^2\mathbf{A} + \nabla(\nabla\cdot\mathbf{A})\right). \tag{2}$$

In (1) and (2), $\mathbf{E}$ is the electric field, $\mathbf{A}$ is the magnetic vector potential, Φ is the electric scalar potential, ω is the angular frequency, and k $(= \omega\sqrt{\mu\epsilon})$ is the wave number. One recalls that (2) follows from (1) through a simple procedure in which the *Lorentz* condition is invoked. In our little example, we focus attention on the z component of electric field E_z ($= \hat{\mathbf{z}} \cdot \mathbf{E}$) created by the $z-$directed current $\mathbf{J} = J(z)\hat{\mathbf{z}}$. On the basis of (2), E_z can be expressed as

$$E_z = -j\omega A_z - \frac{\partial}{\partial z}\Phi \tag{3}$$

while (2) leads to

$$E_z = -j\frac{\omega}{k^2}\left(k^2 A_z + \frac{\partial^2}{\partial z^2}A_z\right). \tag{4}$$

On the z axis, the z component of the vector potential A_z due the current described above can be determined readily from the general potential integral to be

$$\begin{aligned} A_z(z) =& \mu \int_{-h}^{h} J(z') \int_{-\pi}^{\pi} \frac{e^{-jk\sqrt{a^2+(z-z')^2}}}{4\pi\sqrt{a^2+(z-z')^2}} a d\phi' dz' \\ =& \mu \int_{-h}^{h} I(z') K_0(z-z') dz' \end{aligned} \tag{5}$$

in which the total axial current I is defined for convenience to be

$$I(z) = 2\pi a J(z) \tag{6a}$$

and in which the free space Green's function evaluated on the z axis simplifies to

$$K_0(z-z') = \frac{e^{-jk\sqrt{a^2+(z-z')^2}}}{4\pi\sqrt{a^2+(z-z')^2}}. \tag{6b}$$

The electric scalar potential Φ on the axis is

$$\Phi(z) = \frac{1}{\epsilon}\int_{-h}^{h}\int_{-\pi}^{\pi} q(z')\frac{e^{-jk\sqrt{a^2+(z-z')^2}}}{4\pi\sqrt{a^2+(z-z')^2}} a d\phi' dz' \tag{7}$$

where q is the surface charge density that is related to the surface current density by the continuity equation,

$$\frac{d}{dz}J(z) + j\omega q(z) = 0 \tag{8}$$

which allows one to express the potential conveniently as

$$\Phi(z) = j\frac{\eta}{k}\int_{-h}^{h}\frac{d}{dz'}I(z')K_0(z-z')dz'. \tag{9}$$

Substitution of A_z and Φ of (5) and (9) into (3) yields

$$E_z(z) = -j\frac{\eta}{k}\left\{k^2\int_{-h}^{h} I(z')K_0(z-z')dz' + \frac{d}{dz}\int_{-h}^{h}\frac{d}{dz'}I(z')K_0(z-z')dz'\right\} \tag{10}$$

while substitution of A_z of (5) into (4) leads to

$$E_z(z) = -j\frac{\eta}{k}\left(k^2 + \frac{d^2}{dz^2}\right)\int_{-h}^{h} I(z')K_0(z-z')dz' \tag{11}$$

in which η $(= \sqrt{\mu/\epsilon})$ is the wave impedance.

We next wish to manipulate these two expressions for E_z on the z axis into alternate forms which reveal their differences. Under the requirement that the cylinder radius be finite, the integrals in (10) and (11) are sufficiently well behaved that one can interchange the differentiation and integration operations. (This is possible because $\sqrt{a^2 + (z-z')^2}$ is never zero with the observation points on the z axis and the source points on the finite-radius cylinder.) The observation

$$\frac{d}{dz}K_0(z-z') = -\frac{d}{dz'}K_0(z-z') \tag{12}$$

allows one to carry out the following integration by parts:

$$\begin{aligned}\frac{d}{dz}\int_{-h}^{h} I(z')K_0(z-z')dz' &= -\int_{-h}^{h} I(z')\frac{d}{dz'}K_0(z-z')dz' \\ &= -\Big[I(z')K_0(z-z')\Big]_{z'=-h}^{h} + \int_{-h}^{h}\frac{d}{dz'}I(z')K_0(z-z')dz'\end{aligned} \tag{13}$$

Interchanging differentiation with respect to z and integration in the second term of (10) and employing the above integration by parts, with $I(z')$ replaced by $\frac{d}{dz'}I(z')$, one can readily convert (10) to

$$\begin{aligned}E_z(z) = -j\frac{\eta}{k}\Bigg\{ &-\left[\frac{d}{dz'}I(z')K_0(z-z')\right]_{z'=-h}^{h} \\ &+ \int_{-h}^{h}\left\{\left(\frac{d^2}{dz'^2} + k^2\right)I(z')\right\}K_0(z-z')dz'\Bigg\}.\end{aligned} \tag{14}$$

In a similar way, interchange of differentiation and integration plus integration by parts twice (in the manner of (13)) allow one to rewrite (11) in the following form:

$$\begin{aligned}E_z(z) = -j\frac{\eta}{k}\Bigg\{ &-\left[I(z')\frac{d}{dz}K_0(z-z')\right]_{z'=-h}^{h} - \left[\frac{d}{dz'}I(z')K_0(z-z')\right]_{z'=-h}^{h} \\ &+ \int_{-h}^{h}\left\{\left(\frac{d^2}{dz'^2} + k^2\right)I(z')\right\}K_0(z-z')dz'\Bigg\}.\end{aligned} \tag{15}$$

One should observe that (14) and (15) are the same apart from the first term of the latter. *But due to the presence of this term, the expression (14) for electric field E_z on the z axis is different from the expression (15) !* Close inspection reveals that, if $I(h) = I(-h) = 0$, the two expressions are the same. Otherwise, they are not. For example, if $I(z) = cos\, kz$, the identical integral terms of (14) and (15) are zero but the expressions are different unless the cylinder of current is one-half wavelength ($\lambda = 2\pi/k$) in length $2h$ causing $I(\pm h)$ to be zero: $cos(\pm kh) = cos(\pm 2\pi h/\lambda) = cos(\pm\pi/2) = 0$. The two expressions for E_z are the same if the current is zero at both ends $z = h$ and $z = -h$, but, otherwise, they are in general different.

Clearly, both expressions cannot be correct. Which is correct? Why are the expressions the same if $I(\pm h) = 0$? Can the wrong expression be corrected easily?

The paradox, which involves a fundamental principle, will be resolved in the November, 1992, issue of the **ACES NEWSLETTER**. As will be explained, it is important that those who wish to develop **effective** numerical methods to solve the *EFIE* understand this principle and its consequences.

BIO

Chalmers M. Butler is Professor of Electrical and Computer Engineering at Clemson University. He has been a faculty member at Lousiana State University, the University of Mississippi, and the University of Houston. He is a fellow of IEEE, serves as the Chairman of the U.S. National Committee for URSI, and has served two terms on the IEEE Antenna and Propagation Society AdCom. In addition he has served as a member of the editorial boards or as associate editor of the **IEEE Transactions on Antennas and Propagation, Electromagnetics**, the **ACES Journal**, and the **IEEE Transactions on Education**. Professor Butler's major research interest is in mathematical and numerical methods in electromagnetics with principal activity in integral equation techniques. He has published more than 60 journal papers on these subjects.

A SHORT INTRODUCTION TO INTERNET AND ITS USES

OR

IF IT'S A PERSONAL COMPUTER, WHY SHOULD I SHARE IT?

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Introduction

Not so long ago (circa 1975), and in a galaxy not far, far away (this one, in fact), if we wanted to use a computer, we handed over our program to a member of the computer operator's union, after we had spent hours laboriously typing it up on punch cards. After the interminable wait, we would (hopefully) get our output back, which, of course, contained large numbers of arcane error messages (Do any of the younger members know what an ABEND is?). We would then spend anywhere from minutes to days trying to figure out why our program was regurgitated without our expected output. Then we would take back the program and go through the process again. Today, through the miracles of modern science, we have progressed far beyond this. For instance, with the advent of personal computers, we now have "instant" access to our error-ridden output, without a member of the priest class intervening. Another benefit of the personal computer is the opportunity to share the fruits of our labors with others, throughout the world.

The purpose of this article is to give a users overview of the Internet and some of its uses, especially its role as a conduit for transferring files and communicating with individuals around the world. Although reading this won't make you an expert on Internet, networking, E-mail, or file transfers, hopefully it will give you an appreciation of the many capabilities and resources are available through Internet.

What is Internet?

Internet is an interconnected collection of computers around the world that can speak to each other. The language they use is the TCP/IP protocol. Users of any one of the Internet networks can communicate with a user of one of the other networks. Although the Internet started out with what was called ARPANET, today it includes networks such as NSFNET, DDN (Defense Data Net), NASA Science Internet, SURAnet and hundreds of other networks. Additionally, there are gateways to other networks, such as BITNET, FIDONet, UUNET, USENET, Compuserve and MCI Mail.

In the late 1960's, the (Department of Defense) Advanced Research Projects Agency (ARPA, now known as DARPA) funded research into computer networking. One of the results was an interconnected network whereby government, industry and academic computers and networks could be interconnected. The network came to be known as ARPANET. The purpose was to promote easier transfer of information between the various users of the many computer systems that existed then (and now). For instance, in 1981, CSNET was established to provide a mechanism for cooperation between computer and engineering researchers. As time went on and the ARPANET grew in size, it became evident that to easily communicate with other networks, a new architecture was needed. A new network architecture was created and ARPANET became ARPANET Internet. Also, a new communication protocol called TCP/IP was developed.

In 1983 ARPANET was split into two separate networks, MILNET and ARPANET. In 1986 NSFNET began providing service to link supercomputer centers to each other. Today NSFNET has become the national research network. It is a mid level network, linking together networks at many universities and commercial entities. With the growth of NSFNET and other mid level networks, many networks were superseded. In June 1990, the ARPANET was shutdown.

Today, Internet is the term used to describe the collective group of networks which have become the "successor" to the ARPANET Internet. More accurately, the Internet is a network of networks, with the "backbone" managed by Advanced Network and Services, Inc., a non-profit partnership of IBM Corp., MCI Communications Corp., and Merit Network, Inc. Technically, because the networks are government funded, they are for government, research and educational uses only. However, many commercial firms that perform "appropriate research" have access also.

The number of users and the size of Internet is growing each year. There are an estimated 25 million users, with one million people using the Internet daily. Currently Internet access is available in over 33 countries, with thousands of computers acting as host machines. As of January 1990, there were 2,218 networks connected to Internet. According to Boardwatch Magazine, a Littleton, CO based magazine which covers on-line services, last December's backbone traffic averaged over 40 GBytes a day. At this point one might ask the question, "Why are so many people moving so many bits?"

Internet Capabilities and Resources

The Internet provides access to many services, but they can be grouped into four main categories:)1 E-mail, 2) on-line libraries and download capability, 3) bulletin boards, called new groups, where people can enter into discussions by electronic interchange, and 4) remote terminal or login capability, whereby people can log on to other computer systems. In this article, we will focus on the first two areas.

Electronic mail, or E-mail, is one of those rare things that seem capable of fulfilling the promise inherent in the concept. The idea of sitting at your terminal and firing off messages and the results of research to other locations around the world, without having to pay long distance phone charges or being dependent upon the Post Office, has many positive implications for increasing productivity and enhancing the speed with which research is advanced and communicated to other researchers.

E-mail is probably the main reason for the increased usage of the Internet. One of the factors fueling this upswing is the increased interconnectivity with commercial services. Today an Internet user can exchange E-mail not only with other Internet users, but also with users of Compuserve, AppleLink, MCI and other mail/on-line services. Recently the commercial bulletin board system America Online began testing its Internet gateway.

The transfer of files to include downloading software and information from on-line libraries, is the second focus of this article. There are two general ways to transfer files on the Internet. One way is to use your E-mail package. Most packages have the capability of including an "attachment" to the E-mail message. This attachment may be another file, a program, a data set, or whatever. The way this is done will vary from package to package. Chances are you'll have to (gasp) read the manual to determine the package specific actions you are required to take.

A second way of transferring information, hereafter referred to generically as files, is to use what is known as **FTP**. FTP is the acronym for **File Transfer Protocol**, the Internet protocol for moving files from one computer to another. FTP is also the name of a program that machines or operating systems use to carry out the FTP process. Using FTP is relatively straightforward, once you get past the particulars of implementation on your particular machine. Information on using FTP is usually part of the documentation of your system. Below, we will give an example of a FTP session.

Another use of Internet is accessing Interest Groups. These interest groups include bulletin boards (bboards) and mailing lists. The purpose of these bboards and mailing lists is to allow individuals with like interests to easily communicate among each other. Usually there is a moderator or coordinator who oversees a particular bboard or list. The hardest part is often to figure out who the moderator is.

Finally, another major use of Internet is to provide an avenue for remote logins. The program Telnet allows a user at one location to work on a computer at another site. Telnet requires Internet access, which typically means the computer you are using is on a network that has a gateway to the Internet. The key difference between E-mail and FTP, and Telnet is that Telnet allows you to access the commands and programs of the remote host. For instance, you can use Telnet to run a program on a computer that is halfway across the country, or even in another country. Usually the user of Telnet must make arrangements ahead of time to get access to another machine by Telnet. However, some machines are set up to allow any individual to log on and access a restricted subset of the machine's capabilities. Typically you login with a username of anonymous and give your E-mail address as a password.

With this brief introduction to what Internet has to offer, let's take a look at how to use it.

Accessing Internet

Usually the hardest thing about using the services of the Internet is figuring how to go about accessing it. How you access Internet depends upon who and where you are. Most universities and government entities have Internet access. Additionally, many commercial enterprises have access, either through their own machines, or through leased access to providers of Internet service. The best way to find out if you have access is to ask a knowledgeable individual in the computer center where you work. Many people have access, but are unaware of it because they never asked. Once you determine that you have access, you will have to get an account on one of the machines that is on your local network. Once you reach this poing, the actions you take are somewhat site specific. Most users can be divided into two groups: those that are using UNIX as an operating systems and those that aren't.

If you are on a UNIX machine, a fairly common situation, then the remainder of the required actions are very straight forward. Most UNIX sites support the programs **mail**, **ftp**, and **telnet**. Using these programs will allow you to do all the telecommunications your heart desires. To find out mor about these programs, use the on-line manual command **man** to get more information. For instance, to find out more about using the program **mail**, type the following at the system prompt:

% man mail

UNIX users will also find that the downloading process is somewhat familiar, because most FTP commands do the same thing that the equivalent UNIX command does.

If you are using a Macintosh or PC, then a little more effort is required. If your personal computer is tied into a local network, chances are your network has the software you need. Check with the network administrator. If you are operating a stand alone machine, you will have to obtain the necessary communication software for your particular machine. You will have to obtain a program for E-mail and one for file transfer. The ideal program will allow you to do both. There are a multitude of programs available for communications, both commercial and shareware/freeware. Which one you choose is a matter of personal choice. For E-mail, I use a shareware program called Pegasus Mail, while for file transfer, I use Telnet/BYU. However, I am in the process of evaluating several other packages, and may switch to something less "user hostile" in the future.

One program that works quite well for file transfer is the program Telnet. This program is available in both PC and Mac versions. Even better, it is a public domain (i.e. free) program that is available from the National Center for Supercomputing Activities (NCSA). NCSA is the author and keeper of NCSA Telnet, a program that allows the user to upload and download files on the network. The easiest way to get this program is to obtain it from someone who has it locally. Of course it is available for downloading from Internet, but if you don't have it, that makes that somewhat of a problem. The program, as well as other NCSA software is also available by mail. To obtain an order form, send a request to the following address:

FTP Archive Tapes
C/O Debbie Shirley
152 Computing Applications Building
605 East Springfield Avenue
Champaign, IL, USA 61820

or call Debbie at (217) 244-4130

E-Mail

Assuming you have the necessary software, using E-mail is very easy. Once you've learned how to use your particular package, the key thing is getting the right address. The following information, while not essential to using E-mail, will help you understand what is going on.

E-mail was pioneered by the ARPANET, and its format was defined in a document called RFC 822. The format uses what is called SMTP (Simple Mail Transfer Protocol). RFC 822 was designed for sending messages that contained lines of ASCII text. Because RFC 822 was designed to handle only ASCII, there is no support for other character sets, like EBCDIC, as well as no support for handling pictures, facsimile, digitized sound, etc. However, there are ways around this, using clever format conversion routines.

E-mail addresses are based on what is known as a name@domain scheme. All hosts on the Internet are grouped into domains, which in turn are divided into subdomains, which could be subdivided, etc. At the top level of the Internet in the United States, the following five domains exist:

1. COM - Companies, including nonprofit corporations
2. EDU - Educational institutions, like universities
3. GOV - Nonmilitary city, state and federal government agencies
4. MIL - Military organizations
5. ORG - Everything else

Additionally each foreign country is also a top-level domain, and has a two letter code. For example, AU for Australia, CA for Canada, JP for Japan, UK for the United Kingdom, ZA for South Africa, etc.

When trying to decipher my E-mail address, jost@wdc.sri.com everything to the right of the @ symbol identifies the particular address of my machine on the Internet. My E-mail address can be dissected as follows:

name	jost
top level domain	com
subdomain of com	sri
subdomain of sri	wdc

With the name@domain system, the user is not giving a specific routing of how the mail is to be delivered, but rather, the final destination. If you don't have the correct E-mail address of an individual or a host machine, there are mechanisms for obtaining them. We will cover some of these ways in the next article.

File Transfer

The following is an example ftp session. Because I'm a Macintosh user, I've chosen a well known site of Macintosh public domain software. Other locations are oriented toward PC's and UNIX machines. The session shows how to enter the archive, get to the section desired and download some files. The machine's information is in plain Courier type, while the user's response is in **Boldface Helvetica** type.

1. Log on to a host at your site that is connected to the Internet and is running software supporting the FTP command. Once you are connected to the FTP server, the prompt may vary, depending upon the software. For the purpose of this example, I will use ftp> as the ftp prompt. Some software may not give a visible prompt when waiting for a command.

2. Invoke FTP on most systems by entering the Internet address of the desired server. Type the following at the system prompt:

% **ftp sumex-aim.stanford.edu**

or

% **ftp 36.44.0.6**

3. Log in by entering anonymous for the name. If the machine does not give a prompt after the sign on banner, type "user" followed by a return.

Username: **anonymous**

4. Enter your local e-mail address (login@host) for the password.

password: **jost@wdc.sri.com**

5. To find out what other commands are available to you at the command level, type "?" or "help" when you first get into ftp.

ftp> **?**

Usually, there is a "readme" file at the root directory of the network server. This is one of the first things the user should download from any given server. The "readme" file will contain such information as server policies, what is contained on the server, and what to do in case of difficulty.

6. To see what is available, list the files/directories to your screen using the "dir" or "ls" command

ftp> **dir**

7. Change to the Macintosh directory by using the "cd" command and list the contents of the subdirectory:

ftp> **cd info-mac**
ftp> **dir**

8. For additional information about the sumex-aim archive, switch to the help directory.

ftp> **cd help**

9. Enter the following at the "ftp>" prompt to copy a file named "about-info-mac.txt" from the server to your local host:

ftp> **get about-info-mac.txt**

NOTE: Some of the filenames on the sumex-aim server are rather long to aid in identification. Some operating systems, notably MS-DOS, will have problems with names this long. To change the name the file will have on your local machine, type the following at the "ftp>" prompt ("remoteName" is the name of the file on the server and "localName" is the name you want the file to have on your local machine):

ftp> **get remoteName localName**

For example:

ftp> **get about-info-mac.txt macinfo.txt**

10. For files that are not text files (almost everything else) you will need to specify that you want to transfer binary files. Do this by typing the following at the "ftp>" prompt:

ftp> **type binary**

You can now use the "get" command to download binary files. To switch back to ASCII text transfers, type:

ftp> **type ascii**

11. To return to your local host, type "quit" at the ftp prompt.

Hopefully, by now you've managed to logon to another computer and to transfer files from the remote host to the local host. It's at this point, that we run into the next hurdle. If you are transferring text files, then the ASCII transfer format has done what you need and all you have to do is feed it to you favorite word processor. However, if you wish to transfer executable code, then we usually have another process to go through, one of format conversion. Because of the complexity of this topic, it will be held to the next installment.

Program Sources

With thousands of computers on the network, it can be a bit of a challenge to decide where to look for software. The task of locating and downloading software is worthy of an entire article. To get you started, I'll list some locations worth looking at initially.

Site Name	IP Address	Directory	Software
pilot.njin.net	128.6.7.38	/pub/ftp-list	big ftp list
ftp.ncsa.uiuc.edu	141.142.20.50		Telnet
nnsc.nsf.net	128.89.1.178	/resource-guide	what it says
sumex-aim.stanford.edu	36.44.0.6	/info-mac	Mac
rascal.ics.utexas.edu	128.83.1.21	/mac	Mac
wuarchive.wustl.edu	128.252.135.4	/mirrors/msdos	MS-DOS
wsmr-simtel20.army.mil	26.2.0.74	Non-Unix	MS-DOS

When you try to login to a site, if the server has trouble recognizing the site name, use the IP address or vice versa. Sometimes a server will recognize one when it won't recognize the other.

Net Etiquette

Just a short word, on Net Etiquette. Most of the following is common sense (though few things are less common), but very important. Using the Internet is much like driving on the highways. Although you, the driver, aren't personally responsible for its upkeep, how well the system works is very dependent upon the user. Trying to move more cars into a busy intersection that is full, during rush hour, is not very rewarding. The same applies to using the Internet. Careful planning allows for more productive use of limited resources.

For instance, many "anonymous" ftp sites have a limit on the number of users allowed at any given time. The best use of the Internet bandwidth occurs when a user logs into a site, downloads the "readme" and "index" files and looks at those off line. Also, for those living on the East Coast of the US, the best time to download files from West Coast sites is early morning, before net traffic picks up. Most of the bigger software archives are "mirrored" overseas. Thus, if you live in Australia and want Mac software, instead of going to "sumex-aim.stanford.edu," go to the mirrored archive, which is at the site "shark.mel.dit.csiro.au" or 144.110.16.11. This frees up transatlantic bandwidth, which is always in short supply. There are also archives in Europe and Japan and other locations.

Also, realize that many sites are expending resources to allow there systems to be used by anonymous users. Follow the policies of the site when is comes to using the site's computer. When the ftp server asks for your E-mail address as the password, give the correct one, not garbage. It's only by analyzing the usage patterns that net administrators can determine if they are getting the most out of their system. Trying to work around the security systems is in extremely bad taste, not to mention illegal when accessing most government computer systems. We all pay the price if a system decides to go off line because of improper use of computer resources.

Summary

In this article, we've looked at a very brief history of the Internet, a few of its capabilities, and how to use it for E-mail and file transfer. We've looked at how to get on the Internet, and a few locations of interest have been listed. I've also provided some suggestions for additional reading, covering a variety of interest levels. In the next issue of the newsletter, we'll provide an article on locating individuals and host machines on the Internet, how to find software you might be interested in, and how to convert files between different file formats and machine types.

Hopefully, this introduction to the use of the Internet for basic telecommunications has provided an incentive to using the capabilities inherent in the Internet to make you a more efficient computer user. If this article has been of use, please let the editor know of your interest. If the interest is there, additional articles further exploring the use of the Internet can be provided. Also, if you have additional questions, or wish to suggest related topics that could be covered in a future article, please feel free to contact me. The best way to reach me is to send me an E-mail message (of course) at the following address:

jost@wdc.sri.com

For those that don't yet have E-mail capability, I can be reached at

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I hope to see you on the Internet.

Glossary

DOMAIN - A group of computers that share some common identifying characteristic. Used to organize the Internet into a hierarchical structure.

E-MAIL - Electronic Mail. A way to send messages over the computer network.

FTP - File Transfer Protocol. The computer protocols used to exchange files between computers. Also the name of the program to do the same thing.

HOST - A computer set up to be a node on the Internet computer network. Often has the software needed to carry out tasks like E-mail or remote logins.

PROTOCOL - a mutually agreed upon procedure for communicating information between parties.

SMTP - Simple Mail Transfer Protocol

TCP/IP - Transmission Control Protocol/Internet Protocol. The protocols that FTP uses to transfer files around on networks.

TELNET - Program that allows remote login of computer systems

For Further Information

The following publications may be of interest to those wishing further information about the networking, the use of Internet, bulletin boards or e-mail.

"Computer Networks, 2nd ed." by Andrew S. Tanenbaum, Prentice Hall, 1988. More than you probably ever wanted to know about computer networks, but a very good book for those that want the details.

"The BMUG Guide to Bulletin Boards and Beyond" by Bernard Aboba. Available for $20 from BMUG Inc., 1442A Walnut St., #62, Berkeley, CA 94709. Phone (510) 549-2634; fax (510) 849-9026.

"The New User's Guide to Useful and Unique Resources on the Internet". Available for $25 from NYSERNet at 111 College Place, Syracuse, NY 13244. Phone (315) 443-4120; fax (315) 443-1973.

There is an on-line resource guide to the Internet that is available via anonymous ftp from "nnsc.nsf.net" [128.89.1.178]. Discusses most the resources available through Internet, from a list of the major sub networks, to how to access on-line databases. A good place to start.

For Mac users, there is a HyperCard stack titled "Tour of the Internet" that is available on the net via anonymous ftp from nnsc.nsf.net, as well as some of the other Mac archives. It is also available from BBN Systems and Technologies Corp. at (617) 873-3400; fax (617) 873-3776.

Update to the ACES "E-mail database" project

To date (1 June 1992), 17 individuals have responded to my request as outlined in the March issue of the ACES Newsletter. As there were 525 members of ACES as of 31 December 1991, my first impressions would be that there is not very much interest in the capability that is inherent in using E-mail. However, knowing that the members of ACES are computer literate, I will assume other factors, such as time or lack of E-mail capability, are keeping the members from communicating their information to me. About the time you are reading this, I will be sending out a copy of the "E-mail database" to those that have requested inclusion in it. I will be updating the list regularly (at least every other month), so I urge others who wish to be included to send me your particulars (E-mail address, regular address, Fax/Phone numbers, etc.) and they will be included in the next revision.

NEC-MoM Update *

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A long time has passed since there has been any news of developments with the NEC-MoM code, partly because there has been so much code documentation to write that it was hard to find time or enthusiasm for more writing. At last we can report that NEC–4 does exist in essentially final form, although by now many potential users may have written it off as vaporware. The code is currently being tested by the sponsors at Ft. Huachuca and NCCOSC, and plans call for it to replace NEC–3 by around October of this year. Of course NEC–4, like NEC–3, will be subject to the rules of Military Critical Technology, so it will be available to DoD agencies and to contractors only with approval through DoD channels.

NEC–4 includes a number of developments and new features including revised solution algorithms to improve accuracy and numerical precision, updated code structure, new input commands and some modifications to the output. The current expansion and field evaluation for wires in NEC–4 have be changed to correct the loss of precision that occurred in modeling electrically small wire segments with NEC–3. Dipole antennas can now be modeled with the single precision code at frequencies down to where the conductance underflows. However, small loops will remain a problem unless we can put in an option for loop basis and weighting functions.

A serious problem with NEC–3 was inaccurate solutions for stepped-radius wires or junctions of tightly coupled wires. To correct this problem, the thin-wire approximation is now implemented with the current treated as a filament on the wire surface and the boundary condition enforced on the wire axis. With the opposite convention used in NEC–3, the solution tended to converge to a continuous charge distribution at a step in radius, rather than the correct discontinuity in charge based on wire radius. Also, in forming the current basis functions, the charge distribution at a junction is now obtained by solving a small moment-method problem to enforce continuity of scalar potential. This solution takes account of the actual positions and radii of the segments without increasing the size of the structure impedance matrix. It replaces the simple function of the logarithm of wire radius that determined charge distribution in NEC–3.

With the boundary condition enforced on the wire axis, the openings at wire ends should be closed with end caps. This is particularly important when the ratio of segment length to radius is on the order of two or less. Wire ends are closed with flat end caps in NEC–4 with the current and charge density assumed continuous from the wire onto the cap. Also, end caps may optionally be included on voltage sources and segments with impedance loads to reduce the excitation of the inside of the wire. This approximate treatment was found to be about as effective as the extended thin-wire kernel included as an option in NEC–3, so the latter treatment has been dropped from NEC–4.

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* Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Other new features of NEC–4 follow:

- The insulated wire model from NEC–3I is included in NEC–4.
- The SOMNTX program is built into NEC–4, so that if a file with the required data is not found for a Sommerfeld-ground solution the data will be generated for the solution and also written to a file. If multiple frequencies or ground parameters are used in a run, the ground parameters for each case will be computed as they are needed and can also be written to a family of files. The files can then be read sequentially during a subsequent run, to allow fast execution of frequency loops with Sommerfeld ground.
- The solution for large matrices stored on disk now uses direct-access file I/O, so that only a single copy of the matrix must be maintained on the disk. NEC–3, using sequential-access files, needed four copies of the matrix — input, output and two scratch files for Gaussian elimination.
- The option to determine the impedance of a lossy round wire (LD 5,...) accepts the relative permeability of the wire as well as bulk conductivity.
- A group of EX commands can contain a mixture of incident plane wave and voltage source specifications. Incrementing over incidence angles of a plane wave works only on the last plane-wave definition entered in a group.
- The field strength for an incident plane wave can be set on the EX command. The default is 1 volt/m.
- Much of the NEC–4 code has been rewritten to break large routines into smaller modules and to use more Fortran 77 code forms.
- Important array dimensions, such as the maximum number of segments, matrix size and number of segments at a junction are set in PARAMETER statements to make the limits easy to change.
- The input commands are read by a routine that accepts numbers separated by spaces or commas. Text can be added after the data, with an exclamation-mark separator, to document the input lines.
- Commands that require the code to read or write a file (GN, GF, PL and WG) can include a name for the file. The file name is typed after the data, separated by spaces or a comma. If no file name is entered, a default name is used.
- The CM or CE commands can now be used anywhere in the input data to insert documentation into the output.
- The table of charge densities obtained with the PQ command shows the charge at free wire ends as well as at segment centers.
- The maximum-coupling calculation (CP command) now works correctly for structures with non-radiating networks and transmission lines.
- The first integer parameter on the GD command selects the type of cliff: 1 for linear or 2 for circular. When the cliff is specified it will be included in the radiated field calculation; it is no longer necessary to set a flag in the RP command.

- The cliff and radial-wire ground screen approximations, based on plane-wave reflection coefficients, now are used in computing fields due to patches as well as wires.
- A wire with a catenary shape can be generated with the CW command by specifying the end points and either the sag or height at a midpoint or the total wire length.
- The GH command has been changed to generate either a helix or a log or Archimedes spiral. Also, it now works correctly for a flat spiral.
- The GC command, used with GW to define a tapered wire, now accepts either the ratio of successive segment lengths or the length of the first segment.
- The operation of the GM command in moving or duplicating segments can be limited to a range between a starting segment and ending segment. In NEC–3, the range could only be from a starting segment through the last existing segment.
- The code will detect errors such as segments intersecting at midpoints or overlapping or violations of the thin-wire approximation, such as the center of one segment embedded within the volume of another segment.

Along with the work on NEC–4, there has been a small effort to develop graphics tools for visualizing the NEC model and results. Mostly, this has just meant getting plotting programs that we use here into a more useable form, and the results do not rival some of the flashy graphics packages now available. The NECPLOT program, that will read a NEC input or output file and plot the structure, has been extended to plot patches as well as wires. A sample plot for a submarine conning tower was included in the June 1989 ACES Newsletter, although at that time the program did not transform the patch shapes as required by GM, GR, GS or GX commands or handle multiple-patch surfaces, all of which should work correctly now. The program does not check for hidden surfaces, but it does not plot a patch that is seen from the back, so in most cases objects appear solid. Plots of currents induced on a whip on a box and on a sphere with incident plane wave are shown in Figure 1, and other examples were included in Ed Miller's column in the February 1992 IEEE-APs Newsletter. Patches entered with the center-point, normal, area form will not be plotted, since the shape is unknown, but the currents on these patches can still be plotted from a NEC output file. The arrows scale logarithmically with the magnitude of current, with each line representing an order of magnitude.

In response to a PL command, NEC–4 will write a binary file with the model geometry data, structure currents and parameters of the basis functions (the old output produced by the PL command is not available but can be obtained by programs that read the NEC output file.) The program PLT2D3D will read the file produced by PL and plot the wire current or charge using the smooth basis function shape. The plot format can be real-imaginary, magnitude-phase or log-magnitude-phase and plotting can be limited to a range of segments or a particular tag number. PLT2D3D will also produce a 3D plot of the wire structure and currents like that made by NECPLOT.

Program ZPLOT reads a NEC output file and plots the antenna input impedance or admittance versus frequency. It will display multiple curves and will combine and sort data

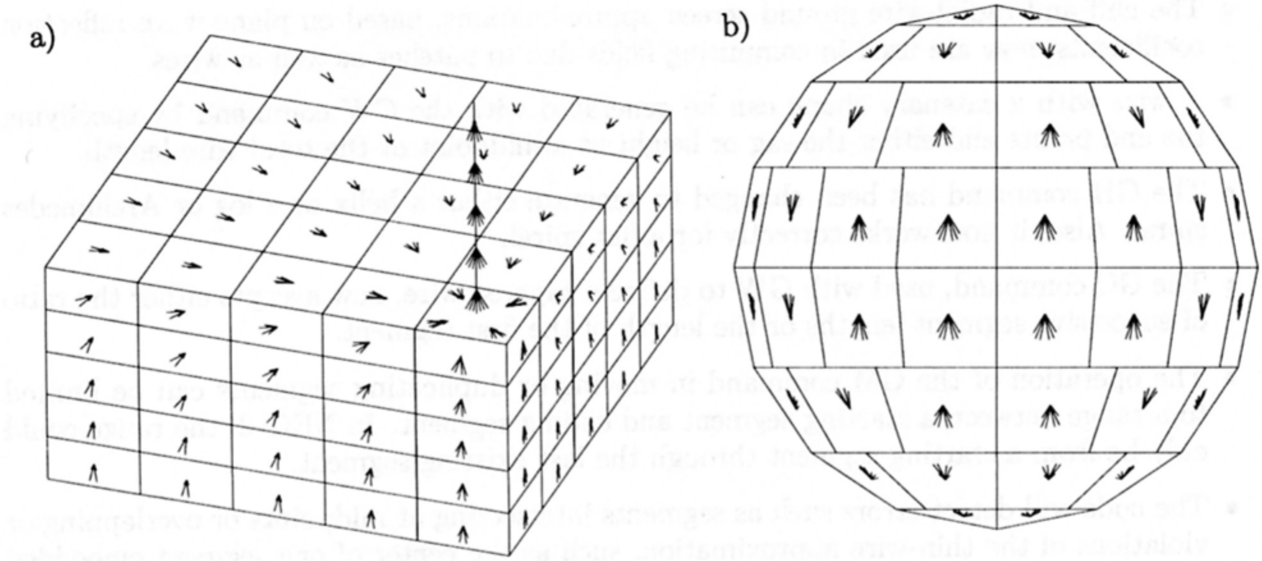

Fig. 1. Plots of current made with program NECPLOT; a) Imaginary part of normalized current on a patch model of a box with wire whip; b) real part of normalized current induced on a sphere with $ka = 2.9$ by a plane wave incident in the direction of observation.

from several NEC runs. Data read into ZPLOT or produced by interpolation can be written to new files in a compact format that can also be read by ZPLOT. An interesting feature of ZPLOT is the use of rational-function interpolation or Cauchy's Method [1], in which a function with the form

$$H(f) = \frac{\sum_{i=0}^{m} a_i f^i}{1 + \sum_{i=1}^{n} b_i f^i}$$

is fit to complex admittance values Y_k computed at N_f sample frequencies f_k. A matrix equation of order $N_f = m + n + 1$ is solved for the coefficients of the numerator and denominator polynomials, and $H(f)$ is then used for interpolation. By default, the orders of numerator and denominator polynomials are $m = n$ for N_f odd or $m = n + 1$ for N_f even. The rational function fit to the data samples tends to match the poles and zeros in the actual response function, and hence can be a very efficient means of interpolation.

The interpolation in ZPLOT operates on a sliding window, so that for N computed frequencies, N_f can have any value from 2 up to N. The value for N_f and the increment by which the window slides can be set with an input command, but the default is $N_f = 7$ and sliding by one interval. Larger values may be effective if the sampling interval is such that the points span more than one resonance. However, if the sampling interval is very small the equations for the coefficients may become ill-conditioned since the solution is attempting to determine more poles and zeros than occur in the vicinity of the sample points. In this case, some of the poles and zeros found may not accurately represent those in the true admittance function. However, the interpolation may still be accurate as long as the poles with largest residues are found accurately.

Rational function interpolation is particularly effective in interpolating narrow resonances, since a single pole and residue can accurately represent a curve that would require a large number of discrete frequency samples. An example is shown in Figure 2 for a forked

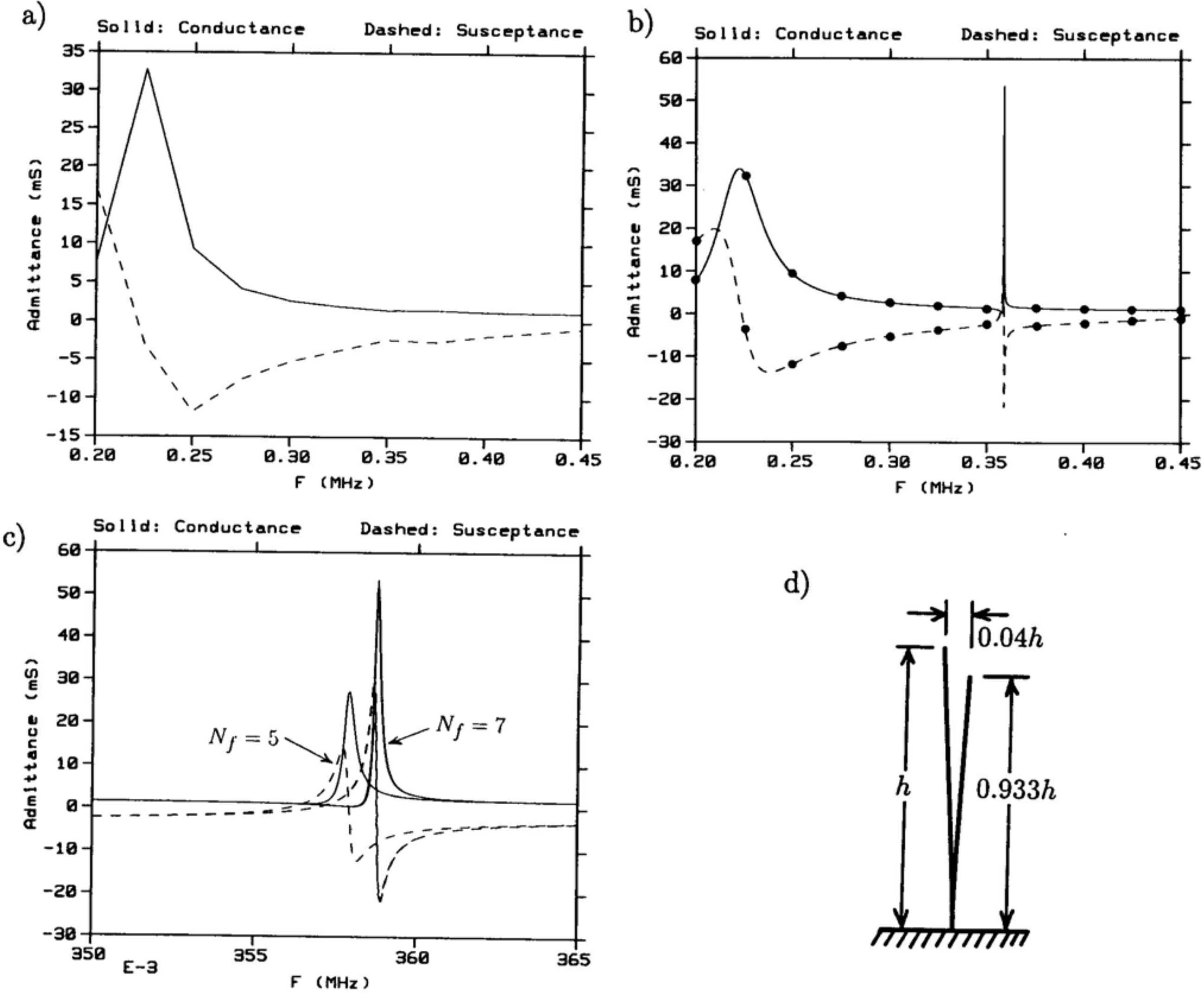

Fig. 2. Plots from program ZPLOT for a forked monopole; a) admittance computed by NEC–4 at 11 frequencies; b) interpolated admittance curve; c) expanded plot of the transmission-line resonance with interpolation using $N_f = 5$ and 7; d) the forked monopole fed at the base.

monopole. This structure exhibits both a simple monopole resonance and a high-Q transmission line resonance due to the unbalanced currents in the two arms. The structure was scaled to make $h = 299.9$ m, so that the frequency in MHz is also h/λ. The curve in Figure 2a, with 11 computed admittances starting at $h/\lambda = 0.2$ with an increment of 0.025, shows a resonance around $h/\lambda = 0.22$. There is also a slight kink apparent around $h/\lambda = 0.36$. Interpolation of this data to 5000 points using $N_f = 7$ reveals the narrow resonance near $h/\lambda = 0.36$, as shown in Figure 2b. The dots have been added by hand to show the original sample points. In Figure 2c the transmission-line resonance is shown expanded with interpolated curves obtained with $N_f = 5$ and 7. A third curve of 41 values computed directly with NEC–4, starting at $h/\lambda = 0.358$ with an increment of $5(10^{-5})$, is included in Figure 2c, and coincides with the interpolated curve for $N_f = 7$.

Determining an appropriate value for N_f is currently done by trial. Too large a value

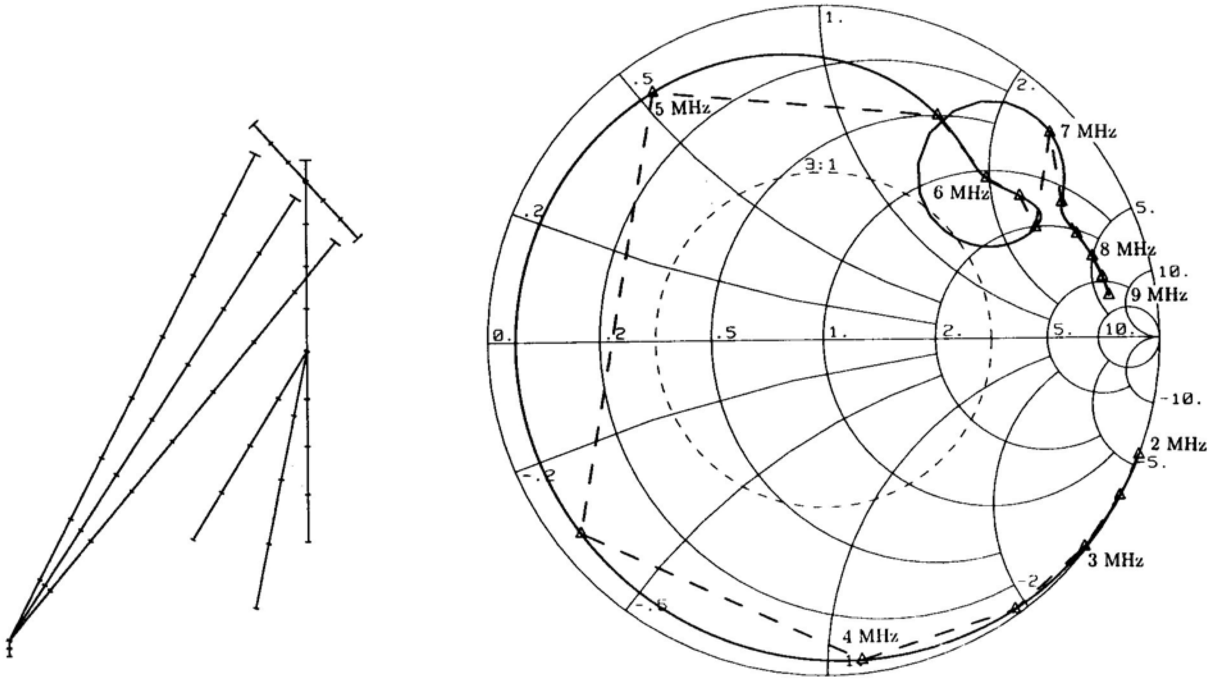

Fig. 3. Input impedance of a bottom-fed fan antenna and mast showing 17 computed points and the result of interpolation. The impedance was normalized to 50 ohms.

may result in an ill-conditioned matrix, while too small a value can sacrifice accuracy. The optimum will depend on the characteristics of the data. Often a sensitivity of the interpolated curve to N_f or to m and n is a sign that more computed values are needed in the region, although in this case the curve for $N_f = 7$ is accurate. By comparing results from different orders of interpolation, it should be possible to develop an addaptive scheme for choosing the frequencies at which to run NEC, although that is getting a long way ahead of the present code.

Program ZPLOT will also plot Smith charts, as shown in Figure 3. The bottom-fed fan antenna shows a main resonance and transmission-line resonance similar to that of the forked monopole. The antenna was first modeled at 1 MHz increments from 2 to 9 MHz. Interpolation revealed the transmission-line resonance around 7 MHz, but the interpolated resistance was negative over part of this region. NEC was then run with 0.5 MHz increments, and the interpolation gave a reasonable resolution of the resonance. Two more frequencies were then computed at 6.95 and 7.05 MHz to better define the narrow resonance. The two NEC files were combined in ZPLOT and interpolated to 5000 points to produce the curve in Figure 3 which is in close agreement with directly computed values. The triangle symbols are plotted by ZPLOT at selected frequencies, but the frequency labels were added by hand. The rate at which the impedance goes around the small loop can be seen from the straight line segments that are evident which represent 1.4 KHz increments.

Another program PATPLT has been set up to read NEC output files and plot radiation patterns. All of these use the Device Independent Graphics Library (DIGLIB) developed at LLNL [2]. DIGLIB is somewhat primitive by modern graphics standards, but it is in the public domain and there are versions for VAX/VMS, Macintosh, MS-DOS and X-Windows. DIGLIB is called device independent because device drivers for common terminals and printers are included and it is relatively easy to write new device drivers using Fortran.

These plotting programs should greatly improve the ability to get information out of NEC results for people who have not already developed similar programs of their own. With NEC–4, we can hopefully look forward to some useful advances in the antenna modeling capabilities. Of course, NEC–4 remains mainly a wire modeling code with limited surface modeling capabilities. A better surface model is badly needed but not presently in the plans. While we hope that NEC–4 will replace NEC–3 around October of this year, it still needs to be released by DoE and DoD, so potential users should not bother inquiring about it at this time.

References

[1] K. Kottapalli, T. K. Sarkar, Y. Hua, E. K. Miller and G. J. Burke, "Accurate Computation of Wide-Band Response of Electromagnetic Systems Utilizing Narrow-Band Information," *IEEE Trans. Microwave Theory and Techniques*, Vol. 39, No. 4, pp. 682-687, April 1991.

[2] H. R. Brand, *DIGLIB – Device Independent Graphics Library*, Lawrence Livermore National Laboratory, CAE Tools and Systems Newsletter, January 1986.

RUN TIMES FOR LARGE NEC PROBLEMS ON A 486 COMPUTER

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Computer run times for NEC-2 problems using thousands of segments on an IBM compatible microcomputer were noted for numerous runs and are shown in the figure below. The computer was a 486-33 MHz Micronics brand EISA motherboard with Weitek math coprocessor and a large amount of memory in RAM and on the hard drive.

The Fortran compiler used was the Microway NDP 386 Fortran compiler version 3.1 with Phar-Lap DOS extender since it offers fast run times as described on page 14 of the March 1992 *ACES Newsletter*. However, new versions of both compilers described in the March Newsletter are now available, so the run times shown below might be faster with a compiler upgrade. Significant speed inprovements could also be obtained with parallel processing hardware and software (see pp. 11-12 of the November 1991 *ACES Newsletter*).

The points plotted in the figure were obtained from numerous actual NEC runs. The curves are not smooth due to differences in the segment separation, use of extended kernel, radiation patterns requested, etc. The curves in the figure are the following cases A through F:

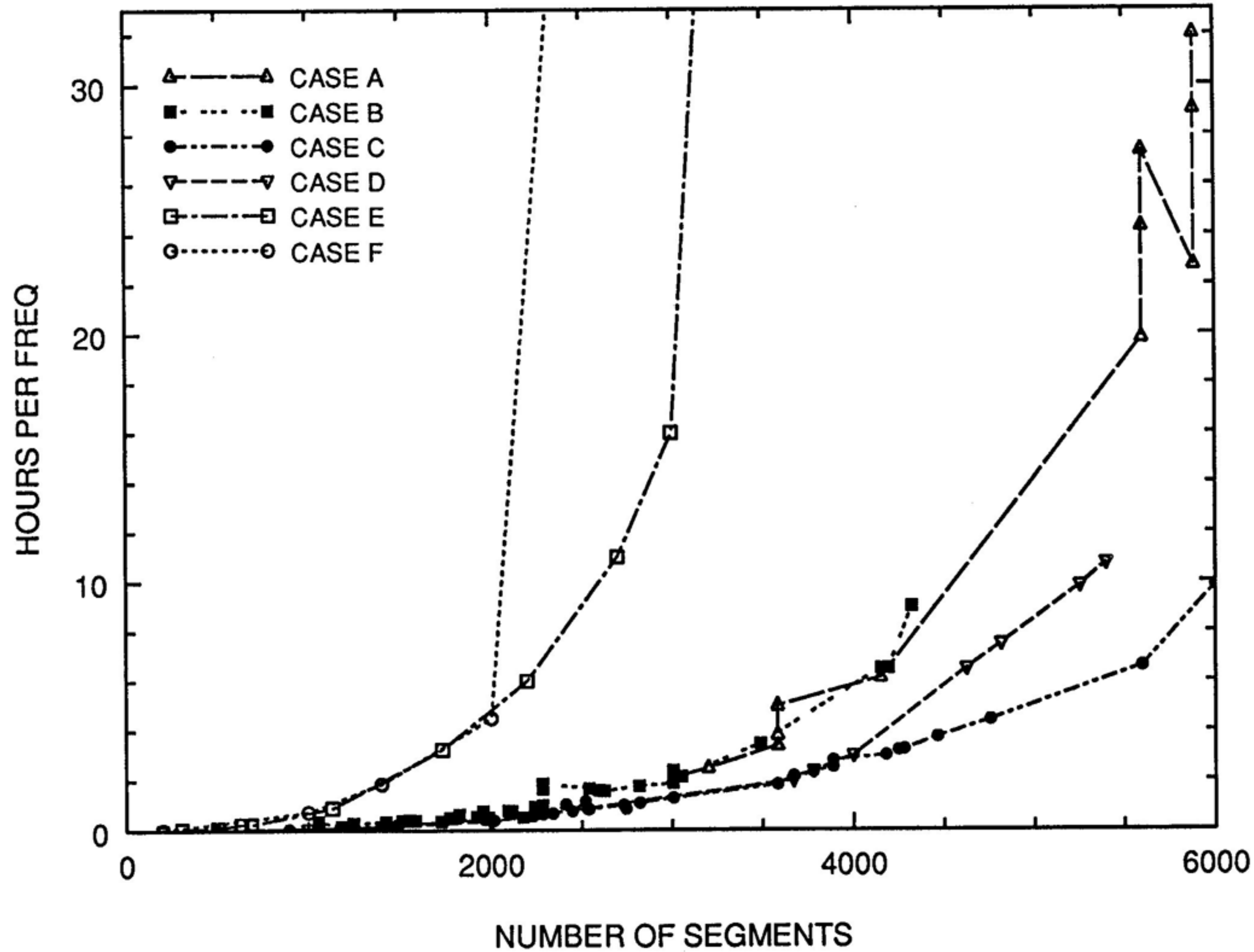
A: 64 MB RAM, SCSI drive, double precision, 4 symmetric sections
B: 64 MB RAM, ESDI drive, double precision, 4 symmetric sections
C: 64 MB RAM, ESDI drive, single precision, 4 symmetric sections
D: 32 MB RAM, ESDI drive, single precision, 4 symmetric sections
E: 64 MB RAM, ESDI drive, single precision, no symmetry
F: 32 MB RAM, ESDI drive, single precision, no symmetry

The figure shows the expected results that double precision runs take approximately twice as long as single precision (Cases A and B vs. C and D). When symmetry is not used (Cases E and F), the runs take much longer.

A comparison of cases C with D and E with F shows that if enough RAM is available for the entire matrix, the run is significantly faster than if the hard drive must be used for virtual memory. The 32 MB RAM cases (D and F) run out of RAM and must use hard drive virtual memory for more than about 4000 segments for case D and 2000 segments for case F. This is in close agreement with the equation for memory requirements shown below.

With 64 MB of RAM, 4300 segments in double precision requires approximately 90 MB of virtual memory on the hard disk. A comparison of cases A and B for approximately 4300 segments shows that there is no significant speed increase when using the SCSI drive as compared with the ESDI drive for 90 MB of virtual memory.

NEC RUN TIMES ON 486 MICROCOMPUTER



For NEC problems, the memory requirements are frequently more of a limitation than the run time. The number of bytes required to store the NEC interaction matrix can be calculated from the following:

$Ir = M^2 B$

$M = N / D^{1/2}$

where

Ir = # of bytes required to store the interaction matrix

N = number of segments used
M = square interaction matrix dimension in number of segments
D = number of symmetric sections, which is equal to
2 raised to the power of the number of planes of symmetry
B = number of bytes required per complex number
(B = 8 for single precision, B = 16 for double precision).

A smaller amount of additional memory is also required for other things besides the interaction matrix. A ground plane (GN nonzero) is handled differently by NEC than a plane of symmetry (GX). The presence or absence of a ground plane has no effect on the size of the matrix (Ir) or on D (# symmetric sections). Absence of ground plane would speed up run times given in the figure by about 10 %.

If the total amount of memory exceeds the available RAM there are two options: NEC's own out-of core algorithm, and allowing the operating system/DOS extender create virtual memory on the hard drive. One or both of these options may not be available depending on computer, operating system, compiler, and NEC version. On my system only the virtual memory option was available, which is probably the faster of the two options anyway. Therefore I dimensioned NEC to accomodate the entire matrix. With no symmetry the number of segments equals the matrix dimension, but with symmetry about the X and Y axis (four symmetric sections) the matrix size can be dimensioned to half the number of segments.

INDEX TO VOLUME 6 OF THE *ACES JOURNAL* AND THE *ACES NEWSLETTER*

This computer code index is updated annually in the second issue of each volume of the ***ACES Newsletter.***

Legend:

AJ	***ACES Journal***
AN	***ACES Newsletter***
*	Pre- or post-processor for another computational electromagnetics code
**	Administrative reference only; no technical discussion (This designation and index do not include bibliographic references.)
page #	The first page of each paper or article in which the indicated code is discussed

NOTE: The inclusion of any computer code in this index does not guarantee that the code is available to the general ACES membership.

ABSTRACTS OF *ACES JOURNAL* PAPERS[1] VOLUMES 1-6

This compilation of abstracts will be updated annually in the second issue of each volume of the ***ACES Newsletter***.

WIRE-GRID MODELING OF SLOT ANTENNAS

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The ability of a computer code to model slot antennas is investigated. A comparison of experimental and numerically calculated antenna data is presented. **[Vol. 1, No. 1 (1986)]**

FOUR-ELEMENT BEVERAGE ARRAY

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An experimental four-element high-frequency Beverage antenna array has been devised for tests on medium range and long range ionospheric circuits. The radiation pattern of the experimental array was calculated using Numerical Electromagnetics Code (NEC) and found to be skewed in azimuth. The antenna installation was subsequently modified in accordance with NEC predictions and the desired beam direction was obtained. Measurements confirmed that the NEC predictions were valid. **[Vol. 1, No. 1 (1986)]**

MININEC APPLICATIONS GUIDE

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The Mini-Numerical Electromagnetics Code -- MININEC has become very popular among amateur and professional antenna practitioners. Its widespread acceptance is due in no small part to its great versatility, user friendliness and extreme compactness which permits installation on PC's. Prior to MININEC, serious numerical modeling of antennas had to be accomplished primarily on mainframe computers. With MININEC, it is now possible to solve complex wire antenna problems in a conversational mode on a modest desk top computer, for example a PC having 64K of RAM. The present paper is concerned with application guidelines for MININEC. The input data set is discussed and numerical results are interpreted. A variety of illustrative linear antenna problems are worked out. **[Vol. 1, No. 1 (1986)]**

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[1]Volumes 1, 2, and 3 were published as the ***ACES Journal and Newsletter***, a combined publication. Abstracts for these volumes include both ***ACES Newsletter*** article abstracts and ***ACES Journal*** paper abstracts, without a "newsletter" or "journal" designation.

MODIFICATION TO MININEC FOR THE ANALYSIS OF WIRE ANTENNAS WITH SMALL RADIUS TO WAVELENGTH RATIO

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MININEC is a useful and compact method of moments antenna program, but MININEC does not give reasonable values for the input reactance of very thin wires at low frequencies. This problem greatly restricts the use of MININEC in the design and analysis of VLF and LF antennas. A modification to the program which eliminates this restriction is discussed. The modification consists of treating both the source and observation segments as filaments and only considering the wire radius when computing the self-impedance. A listing of the changed computer code is included. **[Vol. 1, No. 1 (1986)]**

DREDGING-DEPOSITION, A TWO LAYER GROUND PROBLEM IN MF-RADIO WAVE PROPAGATION

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A limited area in close proximity to an MF broadcasting station was foreseen for deposition of dredging material. The influence that the lossy material with finite height might have on MF propagation was studied. **[Vol. 1, No. 1 (1986)]**

GAIN AND PATTERN MEASUREMENT EXAMPLES OF A LOW PROFILE HF ANTENNA ARRAY

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Measurement data are presented for several configurations of the Eyring Low Profile Antenna (ELPA). The antenna can be classed as an arrayed, broadband antenna with a controlled ground interaction. Examples will demonstrate feedpoint matching, bandwidth, azimuth patterns, elevation patterns and site layout conditions. Eight-element arrays will be compared to typical broadband tactical antennas at several frequencies. The measurements were obtained by a helicopter-towed elementary dipole beacon.

The measurements were performed in the autumn of 1985 at the Eyring Research Institute test facility located at the Cedar Valley Airport, Cedar Valley, Utah. **[Vol. 1, No. 2 (1986)]**

MODELING A RECEIVING MF-HF PHASED ANTENNA ARRAY: NUMERICAL COMPUTATIONS VS FIELD MEASUREMENTS

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A moment method model utilizing the Numerical Electromagnetics Code (NEC version 3) is employed to compute the current vector at the inputs of fourteen active vertical monopoles. The identical antennas are arranged in an "L" (135 m max. aperture), seven to a leg, and non-uniformly spaced. Suspended transmission cables and grounding wires penetrating an imperfect substrate are also modeled. At 0.5 to 5.0 MHz, the cables were found to differentially alter the phase-of-arrival of a polarized arbitrary wave at the antenna inputs.

The phase differences of antenna pairs as computed by NEC and measured in situ are compared for several MF fixed transmitters. Problems of extending the model to shorter wavelengths are also examined. **[Vol. 1, No. 2 (1986)]**

LIGHTNING CURRENT REDISTRIBUTION

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This paper presents a multilevel transfer function approach to determining lightning coupling to aircraft circuitry. The first level transfer function relates the airframe current distribution to the lightning channel current. The second level, which is the principal topic of this paper, relates the current in individual wires and shields in various locations within the aircraft to the total current flowing through the surrounding airframe. The third and innermost level relates voltages and currents at the pin level to wire and shield currents using a transmission line model. The source for each successive level is obtained from the currents computed in the preceding level.

The major part of this paper describes a technique for calculating the current distribution on a structure made up of strips having arbitrary conductivities and thicknesses. It can be used to determine currents on wires or shields located within an aircraft, for example in a cockpit or landing gear bay. The fundamental assumptions limiting the approach are that the structure can be locally approximated as two dimensional, the structure is electrically small in the transverse dimension, and, for fields within a closed surface, the structural thickness is small compared to a skin depth.

The REDIST code developed for the two-dimensional current calculations is described along with verification established by comparison with analytical and measured results. **[Vol. 2, No. 1 (1987)]**

ITERATIVE METHODS: WHEN TO USE THEM FOR COMPUTATIONAL ELECTROMAGNETICS

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The question of when to use an iterative method is addressed from the perspective of the electromagnetics (EM) computer code user. Recent research suggests that, at least in some situations, iterative methods offer significant advantages over direct methods of solution. The circumstances surrounding these situations are investigated, and the features favorable to iterative methods are identified. The paper also includes suggestions for incorporating iterative algorithms into existing computer codes. **[Vol. 2, No. 1 (1987)]**

THE RADIAL FUNCTIONS OF SPHEROIDAL WAVE FUNCTIONS FOR HIGH ASPECT RATIO

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Since the series of the spheroidal Neumann functions and the associated Legendre functions of the second kind converge very poorly at small radial argument ξ for both prolate and oblate, the series expansions of the prolate radial functions in powers of (ξ^2-1), and of the oblate radial functions in powers of (ξ^2+1) are particularly useful in calculating the spheroidal radial functions of the second kind, $R^{(2)}_{mn}$. This paper presents new techniques for obtaining the functions $R^{(2)}_{mn}$ and their coefficients a^{mn}_r contained in the first part and b^{mn}_r in the second part of the functions $R^{(2)}_{mn}$ for prolate as well as the coefficients α^{mn}_r and β^{mn}_r for oblate. In order to compute the scattering by spheroids with high aspect ratio especially for large size parameter, the explicit forms of a^{mn}_r and α^{mn}_r rated therefrom are listed up to r =12, the analytical forms of the coefficients b^{mn}_m (r =m case for b^{mn}_r) at any number m are strictly derived. Having the spheroidal eigenvalues λ^{mn}, the spheroidal angular functions S_{mn}, and the spheroidal radial functions R_{mn}, together with the boundary conditions matching, we can completely solve the problems of electromagnetic scattering from dielectric or metallic spheroids. **[Vol. 2, No. 1 (1987)]**

A SELECTIVE SURVEY OF COMPUTATIONAL ELECTROMAGNETICS

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The continuing growth of computing resources is changing how we think about, formulate, solve, and interpret problems. In electromagnetics as elsewhere, computational techniques are complementing the more traditional approaches of measurement and analysis to vastly broaden the breadth and depth of problems that are now quantifiable. An attempt is made in this article to place some of the tools used in computational electromagnetics into perspective with respect to the different kinds of approaches that may be used and their computer-resource requirements. After a brief background discussion in Section 2, we review in Sections 3 and 4 respectively some of the analytical and numerical issues involved in developing a computer model. In Section 5 we include some practical considerations from the viewpoint of computer-resource requirements, followed by a discussion of ways by which computer time might be reduced. Our presentation concludes with a brief examination of validation and error checking. Emphasis throughout is on review and summarization rather than detailed exposition. **[Vol. 2, No. 1 (1987)]**

GEMACS -- AN EXECUTIVE SUMMARY

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The General Electromagnetic Model for the Analysis of Complex Systems(GEMACS) is a continually evolving computer program developed by the Air Force to accomplish a sophisticated analysis of the electromagnetic field phenomena associated with a given radiating or scattering Air Force system.

Originally conceived to be a tool for use in electromagnetic compatibility (EMC) analysis, it is growing in power and capability into a system of modules that can be applied to the investigation of almost any electromagnetic phenomenon associated with a physical radiating or scattering system.

This paper is meant to be an informational tutorial on GEMACS, without equations, whose sole objective is to acquaint the reader with this powerful, general-purpose, user-friendly electromagnetic fields analysis system.

This paper consists of two separate parts, each dealing with the same material but presented in a

different format to accommodate two broad general classes of reader. The first major division contains little explanatory text and numerous figures and is meant to give a quick overview of the system of GEMACS for those without the time and/or the motivation to get into very much detail. Be forewarned, however, that this first division is meant to give the reader the motivation to find the time and the inclination to read and digest all of the more detailed material in the second part of the paper. **[Vol. 2, No. 1 (1987)]**

BACKSCATTERING FROM A CUBE

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Three analytical techniques -- the method of moments, geometrical theory of diffraction, and physical optics (without fringe current correction) -- are applied to the case of backscattering from a cube. Results are compared to experimental data. It is relatively easy to compute specular scattering with good accuracy; it is much more difficult to obtain good accuracy for corner incidence, which is emphasized here precisely because it provides a more rigorous test of an analytical technique. As expected, the method of moments provides good results when the segmentation is on the order of 0.1 wavelengths, and in some cases up to 0.26 wavelengths. Single-diffraction geometrical theory of diffraction predicts peak scattering within a few dB for a cube dimension of 0.1-3 wavelengths, which is the full range of experimental data, but is not accurate between peaks. Physical optics predictspeak scattering within a few dB for a cube dimension of 1-3 wavelengths, and is also not accurate between peaks. **[Vol. 2, No. 2 (1987)]**

A NUMERICAL EXAMPLE OF A 2-D SCATTERING PROBLEM USING A SUBGRID

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In this paper we present a detailed application of a subgridding scheme for the finite difference time domain (FDTD) numerical solution to Maxwell's equations. The subgridding scheme will be necessary for greater detail and for localized calculations when other methods for the subcell modifications of the regular FDTD are not applicable. We have made comparative calculations, as a function of mesh size, of the reflection coefficient and shunt capacitance associated with two infinite parallel plates with a finite discontinuity in plate separation. **[Vol. 2, No. 2 (1987)]**

MODELLING BY NEC OF AN HF LOG-PERIODIC ANTENNA

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The Numerical Electromagnetics Code (NEC) is a computer code for analysing the electromagnetic response of an arbitrary structure consisting of wires and surfaces in free space or over a ground plane. It is based on the application of the Method of Moments to solve the electric field integral equation. A practical application of NEC which involved calculation of the impedance of a vertically polarised HF log-periodic antenna and comparison with measurements is described. A technique for improving the accuracy of the numerical calculations is discussed in addition to methods for accurately measuringmpedances of antennas employing balanced two-wire transmission line feeders. **[Vol. 2, No. 2 (1987)]**

THE COMPUTATION EXPRESSIONS OF SPHEROIDAL EIGENVALUES

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The higher order terms of eigenvalues in spheroidal differential equations are developed by using power-series expansion and asymptotic ones for both prolate and oblate wave functions. These important multipole expansions greatly facilitate and improve the computations of the electromagnetic scattering by different kinds of spheroids with various size parameters, refractive indices, and aspect ratios. **[Vol. 2, No. 2 (1987)]**

NEAR FIELDS OF A LOG-PERIODIC DIPOLE ANTENNA: NEC MODELLING AND COMPARISON WITH MEASUREMENTS

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Experiences of modelling a log-periodic antenna (tapered transmission line type) using NEC are reported. The antenna is required as a component of a near-field EMC test range, and hence computation of the near fields was the primary objective although some discussion of impedance is presented.

Measurements of the near field of the real antenna were undertaken on a planar measurement range having the ability to scan planes at varying distances from the antenna. The measurements show good agreement with the predictions of NEC. **[Vol. 2, No. 2 (1987)]**

THE APPLICATION OF THE CONJUGATE GRADIENT METHOD TO THE SOLUTION OF OPERATOR EQUATIONS -- AN UNCONVENTIONAL PERSPECTIVE

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This narrative presents an alternate philosophy for the accurate solution of operator equations, you might say "both singular and nonsingular" in general. In this approach, we try to solve the exact

operator equation in an approximate way, quite differently from the matrix methods which try to solve the approximate operator equation in an exact fashion. The advantage of this new philosophy is that convergence is assured and a priori error estimates are available. The conjugate gradient methods are numerical methods which provide a means to reach this new goal, as opposed to an efficient means of just solving matrix equations, which some researchers have assumed them to be. We thereby take the position that there is a heaven-and-hell difference between the application of the conjugate gradient method to solve an operator equation and its application to the solution of matrix equations. **[Vol. 2, No. 2 (1987)]**

CIRCUMFERENTIAL CURRENT VARIATION ON THIN WIRES

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It is shown that wires 1/100 of a wavelength in circumference can have a significant circumferential current variation when scattering an incident plane wave. This variation typically has a very small effect on far-field scattering, but can have a large effect on near-fields very close to the wire. Since the method-of-moments wire technique typically assumes no circumferential variation, this is a potential source of error in some problems. **[Vol. 3, No. 1 (1988)]**

EFFICIENT SOLUTION OF LARGE MOMENTS PROBLEMS: WIRE GRID MODELING CRITERIA AND CONVERSION TO SURFACE CURRENTS

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A banded matrix iterative solution method for linear simultaneous equations arising from thin wire moments problems has been applied to a variety of problems of intermediate electrical size with the number of unknowns ranging up to 1000. Using a convergence criterion of 1 percent, solution efficiencies varied from 2.5 for short, fat objects up to 35 for long, thin objects. Application of the method requires some expertise. Approximate guidelines for wire grid modeling of surfaces have been developed for the moments formalism used. A new method for computing surface currents from grid currents is discussed. **[Vol. 3, No. 1 (1988)]**

SCATTERING ERROR IN A RADIO INTERFEROMETER LOCATED ON A FINITE LENGTH CONDUCTING CYLINDER

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A modified general purpose plate/wire analysis computer program is used to predict the performance of a four-element interferometer mounted on the end cap of a finite length conducting cylinder. The analysis method includes effects of scattering from the cylinder and the antennas. Due to limitations of the computer program a square cylinder is modeled, and the antennas "float" above the end cap. Measurements made of a circular cylinder physical model generally confirm the computer results and show that good performance can be obtained with loop antennas provided that the cylinder exceeds a critical size. **[Vol. 3, No. 1 (1988)]**

ON THE APPLICATION OF THE SECANT METHOD TO THE SPECTRAL ITERATIVE APPROACH

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A new iterative algorithm for calculating the electromagnetic scattering from planar, periodic gratings and grids was developed. Results are compared with the moment method and the Spectral Iteration (S.I.T.) method. The Secant approach is used in conjunction with the Spectral Iteration Approach to achieve convergence. It is shown that the Secant approach, which does not depend on the evaluation of numerical derivatives to achieve convergence like the contraction-corrector S.I.T. method, yields good results. Finally, suggestions for applying this method to two dimensional structures are included and discussed. **[Vol. 3, No. 1 (1988)]**

A DUAL NORMAL MODE REPRESENTATION FOR ELECTROMAGNETIC SCATTERING: SOME INITIAL CONSIDERATIONS

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This paper presents a new technique for characterizing the electromagnetic interaction with and scattering from objects of finite extent. By exploiting the structure of the operators (in this case matrices) associated with the interaction, it is shown that both the system (impedance) matrix and the transfer (admittance) matrix can be partitioned into a sum of two matrices such that each of the resulting matrices can be decomposed into a set of normal modes. As a result, the number of parameters needed to describe the interaction is now significantly reduced and the parameters identified by this technique are model independent, i.e. they are measurable parameters. Potential applications of the technique include EM computations, compact descriptions of scatterers and antennas, interpretation of measured data, and algorithm development applicable to scattering and inverse scattering problems. **[Vol. 3, No. 2 (1988)]**

COMPARISON OF METHODS FOR FAR ZONE SCATTERING FROM A FLAT PLATE AND CUBE

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Different high frequency methods are used to analyze the backscatter and bistatic scattering from a flat plate and a cube. The results are compared and their validity is checked against method of moments and measurements. A newly developed far zone corner diffraction coefficient based on the latest equivalent current and PTD solutions cast in UTD form is discussed. **[Vol. 3, No. 2 (1988)]**

ON THE COMPARISON OF NUMERICAL METHODS

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Serious comparisons of numerical methods are important for scientists who develop new codes as well as for those who use programs. Historical considerations show some errors which were made in the past and should be avoided in the future. Every numerical code is based not only on numerical but also on analytical considerations. Both of them have to be taken into account. As a result, benchmarks for complicated topics (numerical calculations of electromagnetic fields) should give more information than just numbers like 'speed', 'memory requirement', etc. **[Vol. 3, No. 2 (1988)]**

IMPLEMENTATION OF GEMACS 3.3 ON PERSONAL COMPUTERS

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GEMACS 3.3 is a powerful MM/GTD hybrid package which can model a wide range of antenna and scattering problems. It is intended for use on large mainframe computers but an implementation on a personal computer has advantages in the possibilities of interactive use and graphical output. An approach to this implementation is presented, together with benchmark test results from typical PCs, a mainframe and a supercomputer. **[Vol. 3, No. 2 (1988)]**

OBTAINING SCATTERING SOLUTIONS FOR PERTURBED GEOMETRIES AND MATERIALS FROM MOMENT METHOD SOLUTIONS

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In this paper, we present an efficient method for computing the solution to scattering problems using a perturbation scheme based on the solution of related original problems. Assuming the radar cross section has been computed for a particular scatterer associated with a moment method matrix B, we call the computation of the radar cross section of a slightly perturbed scatterer a "perturbed problem of B". If the original problem has n unknowns, and the perturbed problem is formed by changing p cells of the original problem, then our method requires an operation count of $O(n^2p + p^3)$ while a direct moment method solutions requires an operation count of $O(n^3)$. Our method involves application of the Sherman-Morrison-Woodbury formula for inverses of perturbed matrices. We show that the method can be easily implemented in any moment method code, and the user does not have to learn a new input procedure.

Further, the modified code can provide a basis for a non-linear optimization procedure which minimizes the radar cross section of an obstacle by varying the surface impedances. An appropriate objective function in this problem depends on the radar cross section at the angles and frequencies of interest. Let n be the number of cells in the obstacle and let p be the number of cells with variable impedance, with n>>p. Then application of the Sherman-Morrison-Woodbury formula results in objective function evaluations requiring an $O(np+p^3)$ operation count. In contrast, application of the classical moment method results in objective function evaluations requiring an $O(n^3)$ operation count.

Numerical results from large practical problems demonstrate the efficiency and stability of the new method. **[Vol. 3, No. 2 (1988)]**

THE EFFECTS OF HEAVY CHARGED PARTICLE IRRADIATION OF MOSFET DEVICES

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Ionizing cosmic particle radiation poses a serious threat to electronic devices (such as metal-oxide semiconductor, field effect transistors -- MOSFETs) that are used in outer space. The physical process in which a bombarding ion creates electron-hole pairs in the SiO_2 layer of a MOSFET, the subsequent collection of charge at the SiO_2-substrate interface and its effect on the operating characteristics of the transistor is modeled with two second order, coupled differential equations. The coupled equations are solved using the finite difference technique known as the Alternating Direction Implicit Method, ADI. Preliminary verification of the computer code was performed using a low energy proton accelerator. The measured change in MOSFET operating characteristics compared favorably with the predicted results. The results show that the damage due to ionizing particles is greatly dependent on the energy of the bombarding particle, its angle of incidence, and the magnitude of the bias applied to the MOSFET. **[Vol. 3, No. 2 (1988)]**

HF GROUND CONSTANT MEASUREMENTS AT THE LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) FIELD SITE

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The SRI International open-wire-line (OWL) kit was used 3-5 July 1987 to measure the HF ground constants at the Lawrence Livermore National Laboratory (LLNL) field site in Livermore, CA. Data were acquired at 11 locations about 250 ft west of the LLNL facility fence in the vicinity where a longwire and broadband dipole were erected in August 1987 for making impedance measurements for the purpose of validating the Numerical Electromagnetics Code (NEC). An additional location was measured to the north of the antenna site where field strength data were to be taken. Several samples were taken at most locations. Best estimates of the conductivity, relative permittivity (relative dielectric constant), dissipation factor and skin depth were computed as the median values versus frequency for 2 through 30 MHz. Data were acquired at 1-MHz intervals from 2 MHz through 8 MHz, and the interval was increased to 2 MHz from 8 MHz to 30 MHz. The maximum and minimum values were also determined as bounds on the conductivity and relative permittivity values for use in parameter sensitivity analyses. The conductivity values for the relatively dry, densely packed light brown clay fell between those typical of pastoral land and rich agricultural land at about 4x10-2S/m. The relative permittivity values exhibited more variation with frequency. At the low end of the HF band, the relative permittivity values exceeded those of a non-flooded rice paddy (e.g., about 150 at 2 MHz); whereas, at the high end of the band, the relative permittivity approximated values typical of rich agricultural land (about 17 at 30 MHz). The skin depth varied from about 2 m at 2 MHz to 0.7 m at 30 MHz. The dissipation factor was about 1.5, so the soil acted almost as a semiconductor rather than as a lossy conductor or a lossy dielectric. Both the relative dielectric constant and conductivity are important in modeling antennas and propagation over the ground at the LLNL site. Data from nearby wells indicated that the water table was at least 20 m below the surface. Therefore, a one-layer slab model adequately described the ground at this site for HF down to the skin depth. [Vol. 3, No. 2 (1988)]

CHARACTERIZATION, COMPARISON, AND VALIDATION OF ELECTROMAGNETIC MODELING SOFTWARE

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The continuously increasing number of electromagnetic computer models (codes) and applications thereof is one result of a rapidly expanding computing resource base of exponentially growing capability. While the growing use of computers in electromagnetics attests to the value of computer modeling for solving problems of practical interest, the proliferation of codes and results being produced increased the need for their validation with respect to both electromagnetic formulation and software implementation. But validation is perhaps the most difficult step in code development, especially for those models intended for general-purpose application where they may be used in unpredictable or inappropriate ways. A procedure or protocol for validating codes both internally, where necessary but not always sufficient checks of a valid computation can be made, and externally, where independent results are used for this purpose, is needed. Ways of comparing differing computer models with respect to their efficiency and utility to make more relevant intercode comparisons and thereby provide a basis for code selection by users having particular problems to model are also needed. These issues are discussed in this article and some proposals are presented for characterizing, comparing, and validating EM modeling codes in ways most relevant to the end user. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

DIFFICULTIES ENCOUNTERED WHEN ATTEMPTING TO VALIDATE THIN-WIRE FORMULATIONS FOR LINEAR DIPOLE ANTENNAS

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When analyzing wire antennas, the "thin-wire" kernel is often used as a convenient approximation to the exact singular kernel in the electric-field integral equation. In this paper, it is shown that the thin-wire kernel is a poor approximation to the true kernel, but its use does yield good values for input impedance over a significant range of parameters (e.g., wire radii, size of subsectional cells). The validity of the thin-wire kernel when used within the electric-field integral equation appears to be due to the fact that the approach is often a good approximation to the Extended Boundary Condition (EBC) formulation. Although it is often implied in the literature that use of the thin-wire kernel will produce "convergent" values for input impedance, in actuality there is no guarantee that results improve as more cells are taken along the wire. Despite widespread use of the "thin-wire" kernel, there are inherent difficulties in the validation of codes based on this approximation. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

EVALUATION AND VALIDATION OF THE METHOD OF MOMENTS CODE NEC2 IN THE DESIGN OF LOG PERIODIC DIPOLE ARRAYS WITH LOW SIDELOBE LEVELS FOR BROADCAST APPLICATIONS

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The evaluation and validation of the Method of Moments Numerical Electromagnetics Code (NEC2) is undertaken by the comparison of measured and computed radiation patterns of Log Periodic Dipole Arrays. Emphasis is placed on the correspondence of the sidelobe levels -30 to -40 dB down from the major lobe. This paper is concerned with the evaluation of a single antenna in free space. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

MOMENT METHOD ANALYSIS OF RADIATION AND SCATTERING BY THIN WIRES IN AN INFINITE DISSIPATIVE MEDIUM

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In this report, a modified version of AMP (Antenna Modelling Program), a forerunner of NEC (Numerical Electromagnetics Code) is validated for applications involving thin wire structures immersed in an infinite dissipative medium. A Pascal derivative of MiniNEC2, the Mini Numerical Electromagnetics Code, is also used to provide numerical comparison as needed when other data are not available. Computations from both programs are compared with analytical and pre-existing experimental results. Drive point impedances, currents and near fields for a range of thin wire radiators and scatterers are presented. Useful results are obtained for the highest conductivity case tested ($\delta = \sigma / \omega\varepsilon_0\varepsilon_r = 8.8$) and for less conductive media, agreement of computed parameters with available comparative data of approximately 10% or better is achieved. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

A COMPARISON OF TWO EUROPEAN REFLECTOR ANTENNA CODES

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Two computer programs for the analysis of reflector antennas are evaluated for the purposes of establishing their general capabilities and, more specifically, accuracy and computational efficiency. Both programs were used to analyse a number of test cases and the results obtained are compared. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

COMPARISON OF ELECTROMAGNETIC SCATTERING SOLUTIONS USING THE DISK AS A TARGET

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Results are compared for scattering from a perfectly conducting circular disk using three solutions: A closed form physical optics (PO) solution, a Physical Theory of Diffraction (PTD) Solution, and a computer implementation of an exact eigenfunction solution. The far field patterns are compared for various ka values as well and incidence angles for both vertically and horizontally polarized electric fields. For normal incidence, the solutions agree very well. For small ka the agreement is remarkable. As ka increases, the agreement is still good as long as the observation angle θ does not exceed 45o.

The applicability of using the disk as a target to calibrate an RCS measurement range is discussed. The disk calibration curve is a plot of the specular return as a function of bistatic angle. This curve is computed for both horizontal and vertical polarizations and various ka values using the PO and eigenfunction solutions. The specular bistatic RCS (calibration curve) is relatively invariant; hence, the disk is an ideal candidate as a calibration standard for bistatic RCS measurements. Agreement between the PO and eigenfunction solutions for large ka means there is an easy method of generating the applicable calibration curve for a particular disk as long as one remains within the valid angular region for a proper size disk. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

VALIDATION OF A Z-MATRIX FINITE ELEMENT PROGRAM FOR ANALYZING ELECTROSTATIC FIELDS

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Modern electrical equipment designs demand more compact, complex geometries and require more stringent analyses of the associated three-dimensional electrostatic fields. Analytical solutions of such fields are limited to relatively simple geometries. Numerical solutions using the finite element method are limited by available computer storage and processing time. Lauber posed an economical method for solving three-dimensional finite element electrostatic fields by forming the finite element system matrix using Brown's Z-matrix techniques. (Lauber, 1982) (Brown, 1975) This method was implemented by a FORTRAN computer program. (Barber and Lauber, 1986) (Barber, 1988) The purpose of this paper is to briefly describe the present version of the program called FEWZ (Finite Elements using a Window and the Z-matrix) and to show how it was validated.
[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]

THE COMPARISON OF A TIME-DOMAIN NUMERICAL CODE (DOTIG1) WITH SEVERAL FREQUENCY-DOMAIN CODES APPLIED TO THE CASE OF SCATTERING FROM A THIN-WIRE CROSS

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In this paper we compare, via Fourier transform, results obtained using the DOTIG1 time-domain numerical code with those obtained using several frequency- domain thin-wire codes [1] and with the experimental measurements obtained by Burton [2], specifically applied to the scattering from a cross. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

THE VALIDATION OF EM MODELING CODES A USER VIEWPOINT

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Computer codes for solving radiation and scattering problems have become powerful and widely available. The user of such a code must initially convince himself that his copy of the code executes correctly on his specific computer with his particular compiler. He must then build up expertise in constructing models for solution by the code which obey the restrictions imposed by the "modelling guidelines" accompanying the code in a user's manual. Users often want to solve "real" problems that do not conform to the problem geometry envisaged by the code writer. The user replaces the "real" structure with a computer model solvable by the code, and which obeys the modelling guidelines. The user must then carry out a "model validation" in which the computer model is tested against full-scale or scale model measurements. A successful "model validation" contributes to the user community's "experience base" and lends confidence to both the computer code and to the modelling process. Sometimes an unsuccessful attempt at modelling exposes a genuine limitation of the code. Then a new "modelling guideline" can be formulated to aid other users in avoiding the

same difficulties.

This paper reviews code development to highlight the origin of "modelling guidelines", and how they are extended by the user community. From the user's point of view, the "experience base" is augmented whenever a successful "model validation" is carried out and reported. Several examples are presented of the difficulties that may be encountered in computer modelling, and how such difficulties lead to further "modelling guidelines" aimed at aiding others in solving similar problems. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

WIRE GRID MOMENT METHOD (NEC) MODELS OF A PATCH ANTENNA

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Wire grid models of an air-loaded resonant circular patch antenna are used to calculate several observable quantities. The resonant frequency, input reactance, and bandwidth are accurately calculated, but the input resistance is underestimated by the grid models due to the existence of separate currents on both the top and bottom of the measured solid patch. The Lawrence Livermore (NEC3) Method of Moments computer program was used to generate the grid models. Average wire lengths of about .03 λ are required for accurate results. A comparison with other studies suggests that the .03 λ segmentation may be required because the patch is close to the ground plane (.0175 λ), and/or because errors in the near field calculation are compounded by the large fraction of energy stored in the near field since the patch is a high Q resonator. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

WHAT DO YOU MEAN BY A SOLUTION TO AN OPERATOR EQUATION?

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The main thrust of this presentation is to illustrate that for many electromagnetic field problems the quality of the solution is very subjective and not objective at all. Therefore to classify solutions on a subjective criteria which is not scientific will create more problems than it would solve. The underlying feature to all this is what do "we mean" by a solution. **[Special (Supplemental) Issue on Electromagnetic Computer Code Validation (1989)]**

A VOLUME INTEGRAL CODE FOR EDDY-CURRENT NONDESTRUCTIVE EVALUATION

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This paper is an extension of J. R. Bowler, H. A. Sabbagh, and L. D. Sabbagh, "A Computational Model of Eddy-Current Probes Over a Stratified Composite Workpiece," which was presented at the 4th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, March 1988. It describes an application of modern methods of computational electromagnetics to the problem of eddy-current nondestructive evaluation (NDE). Specifically, a volume integral equation is developed that can be used to model eddy-current probes with ferrite cores, or it can be used to compute flaw-field interactions. Both of these problems are of considerable importance in applying electromagnetic techniques to NDE, for they are intimately involved in detecting flaws, and inverting eddy-current data for reconstructing flaws.

The model is fully three-dimensional, and the discretized integral equation is solved iteratively using conjugate gradients and FFT techniques. Problems with 12,000 unknowns are being routinely solved

on the Alliant FX/1 minisupercomputer in reasonable times. The model is used to compute such important probe parameters as impedance and coupling. It is also used to compute the electromagnetic response of flaws as the geometry of the flaw changes, or as a function of frequency. **[Vol. 4, No. 1 (1989)]**

EIGENVALUE COMPUTATION FOR APPLICATION OF THE FINITE HANKEL TRANSFORM IN COAXIAL REGIONS

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The evaluation of eigenvalues for transcendental equations in the cylindrical coordinate system is considered. A new code has been developed for this purpose. This is a fast algorithm for finding contours of a real function of two variables. This algorithm searches for the interval in which the function passes through the desired reference value and subsequently automatically starts to trace the contour within a circular annulus region of interest. When the reference value is zero and the function represents the limiting form of the Finite Hankel Transform kernel, the solution of the transcendental equation for eigenvalues is obtained. For accurate values of proper numbers, another code provides them with the desired uncertainty. Numerical results are presented and compared with available data. The computed eigenvalues may be used to obtain solutions of boundary value problems for circularly-symmetric electromagnetic waveguides, cables, cavities or scatterers. **[Vol. 4, No. 1 (1989)**

GTD ANNULAR SLOT ANTENNA MODELS AND WIRE SCATTERING

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Antenna patterns were calculated for two computer models of an annular slot antenna using the Basic Scattering Code (BSC) implementation of GTD. The patterns are compared with a measured pattern. The two computer models are a small electric monopole and a ring of rectangular slots. The monopole model showed good agreement with the measured pattern. The monopole was also used to compute GTD scattering from a thin cylinder, and the results compared with a more accurate field calculation using the Method of Moments. **[Vol. 4, No. 1 (1989)]**

THE EQUIVALENT CIRCUIT OF A MICROSTRIP CROSSOVER

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The equivalent circuit of a microstrip crossover is found. Integral equations are obtained for the densities of excess charge, and these equations are solved by the method of moments. Introduction of a specified transverse distribution of charge, which satisfies the edge condition, reduces the computing time dramatically while the accuracy remains excellent. Several plots of the excess charge densities are provided along with numerical values of lumped excess capacitances. **[Vol. 4, No. 1 (1989)]**

SCATTERING AND ABSORPTION OF ARBITRARILY ORIENTED DIPOLES WITH FINITE CONDUCTIVITY

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Plane wave scattering of lossy dipoles oriented arbitrarily in space is analyzed with the NEC-2 code. Modification of the code allows computing not only the radar cross section but also scattering and absorption cross section. With these electromagnetic characteristics it is possible to describe the relation between reradiated and absorbed power of the scatterer as a function of frequency and conductivity. A comparison with the results obtained with other codes (MININEC, Richmond) shows substantial differences at higher resonances of the dipoles. **[Vol. 4, No. 2 (1989)]**

COMBINED-FIELD FORMULATION FOR CONDUCTING BODIES WITH THIN COATINGS

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A Galerkin method-of-moments (MM) formulation is developed for the problem of electromagnetic scattering from a conducting body with a thin coating. The formulation incorporates both the electric-field integral equation (EFIE) and magnetic-field integral equation (MFIE) formulations on the conductor and the dielectric surfaces. The formulation is developed in terms of generalized Galerkin matrix operators which allow for straightforward implementation into existing computer codes for coated bodies. The analysis allows a surface coating of nonuniform thickness that is characterized by complex permeability and permittivity; the analysis can be easily extended to the case of a thin multilayered body.

Standard MM formulations for coated bodies, based on either the EFIE or the MFIE at the conductor surface, fail as the coating thickness approaches zero. The combined-field integral equation (CFIE) also fails in the limit of zero thickness. The present thin-coating formulation (TCF) will be shown to remain valid as the coating thickness approaches zero. In the limit, the matrix equation for the TCF reduces to a self-consistent set of equations for scattering from a conducting body, independent of the dielectric coating parameters.

The TCF has been implemented for the case of scattering by a conducting body of revolution (BOR) with a thin dielectric layer. Examples are presented comparing the present formulation to other MM formulations. The TCF is demonstrated near internal resonant frequencies, and for some limiting cases for both bistatic and monostatic scattering. **[Vol. 4, No. 2 (1989)]**

A 2-D FINITE ELEMENT MODEL FOR WAVE PROPAGATION INTO ARBITRARY INHOMOGENEOUS MATERIALS

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A finite element program called FEAST, coded in FORTRAN, provides a frequency domain (sinusoidal steady state) solution to Maxwell's equations in cylindrical coordinates. By imposing a radiation or impedance boundary condition at the far boundary of the finite element mesh, FEAST models the near fields of axially symmetric antennas in arbitrary inhomogeneous materials. The program has been validated by reproducing the driving point impedances and current distributions of several antenna configurations for which theoretical and experimental results are available in the published literature. **[Vol. 4, No. 2 (1989)]**

AN ANISOTROPIC TWO-DIMENSIONAL SCATTERING CODE

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A computer code has been developed to predict radar return from two-dimensional cylindrical targets composed of anisotropic, lossy, and inhomogeneous materials. A moment method formulation uses point matching with rectangular domains of pulse basis functions for volumetric elements. Targets may also be composed of thin films including conducting sheets. Particular attention is paid to problems associated with close coupling which involve numerical integration over neighboring domains of basis functions, rectangles which may be very close together as in the case of thin layers of material.

Examples are used to show that analytical integration of singularities associated with close coupling gives results which are superior to the numerical approximations used in typical moment method codes.

The results are of interest for problems involving isotropic as well as anisotropic targets. For example, when a code which calculates close couplings with numerical approximations is applied to a hollow, conducting cylinder, computed radar return may be distorted by introducing conducting elements close to the interior wall of the cylinder. With analytical treatment of singularities, however, there is no distortion. In another example results from codes are compared for the case of a right circular cylinder coated with anisotropic material. Results in good agreement with a series solution taken from the literature are achieved when analytical treatment of singularities is considered. Finally, for the example of a conducting plate it is shown how analytical treatment of singularities makes good results possible for a minimum number of basis functions. **[Vol. 4, No. 2 (1989)]**

A HYBRID FINITE ELEMENT FOR CONDUCTORS WITH THIN DENSE COATINGS

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A hybrid method of using finite elements and boundary integral methods to compute scattering from two dimensional coated conductors is presented. Finite elements are used in and around an electrically dense coating where high sampling rates are required. Since the matrix equations they generate are sparse, they can be quickly solved. The finite element sampling rate is reduced with distance from the scatterer to a very low rate where the boundary integral method provides the exact near field radiation condition. The boundary integral generates a dense matrix which is small due to the reduced sampling. This technique is compared for accuracy and efficiency with series solutions and with method of moments. **[Vol. 4, No. 2 (1989)]**

SOME CONSIDERATIONS ON THE USE OF NEC FOR COMPUTING EMP RESPONSE

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This paper concerns the use of a frequency domain code such as the Numerical Electromagnetics Code (NEC) for computing the time domain EMP response of structures such as antennas, aircraft or communication shelters. The effects of the choice of a proper model for the excitation and of the selection of an appropriate number of frequencies for taking an inverse FFT and obtaining a correct time domain EMP response are studied. Guidelines are given for obtaining a correct time domain

response with efficient use of computer time. **[Vol. 4, No. 2 (1989)]**

A THIN DIPOLE ANTENNA DEMONSTRATION OF THE ANTENNA MODELING CAPABILITIES OF THE FINITE DIFFERENCE TIME DOMAIN TECHNIQUE

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The Finite Difference Time Domain (FDTD) technique has been successfully applied for modeling the electromagnetic scattering from and coupling into a variety of objects. In this communication we use FDTD to compute the input impedance of a thin dipole antenna. The short circuit current and open circuit voltage at the antenna terminals are computed over a wide bandwidth using pulsed plane wave excitation, then Fourier transformed to the frequency domain and divided to obtain the complex input impedance over a wide bandwidth using one FDTD computation. These results are compared with thin wire antenna results using the Method of Moments and good agreement is obtained except at very low frequencies, where the FDTD results obtained using this approach lose accuracy due to the imperfect outer absorbing boundary. **[Vol. 5, No. 1 (1990)]**

MODELING ELECTRICALLY SMALL, THIN SURFACES WITH WIRE GRIDS

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Wire grids are widely used to model conductive surfaces. Wire grid models reported in the literature have primarily addressed electrically large or resonant configurations. Electrically small surfaces, however, can also have a significant effect on radiation characteristics and these surfaces are often difficult to model using other methods. A structure containing an electrically small, thin plate with wires attached to both sides is analyzed using different wire-grid models. The thin plate is modeled as either an open or closed surface using single and double-layer grids. Comparing the model results with measurements suggests that a closed surface (double-layer) grid may be more accurate and efficient than an open surface (single-layer) grid in many cases. Unlike single-layer grids, double-layer grids do not permit current to flow through the surface and hence enforce an important boundary condition. **[Vol. 5, No. 1 (1990)]**

A LIMITED COMPARISON OF PREDICTED AND MEASURED RESULTS FOR AN HF GROUND-ARRAYED LOG PERIODIC DIPOLE ARRAY

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Measurements of the in-situ radiation pattern of a full scale horizontally polarised HF log periodic antenna are compared with predicted results from two different computer programs. The limited results suggest that more attention should be paid to ground effects at low take-off angles. While the predicted results are in good agreement with each other for take-off angles below the peak of the pattern, they tend to diverge above the peak. **[Vol. 5, No. 1 (1990)]**

RADAR ANTENNA PATTERN ANALYSIS FOR THE SPACE SHUTTLE USING NEC-BSC

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In order to improve tracking capability, radar transponder antennas will be mounted on the space shuttle solid rocket boosters (SRB). These four antennas, each being identical cavity-backed helices operating at 5.765 GHz, will be mounted near the top of the SRB's, adjacent to the intertank portion of the external tank. The purpose of this study is to calculate the roll-plane pattern (the plane perpendicular to the SRB axes and containing the antennas) in the presence of this complex electromagnetic environment.

The large electrical size of this problem mandates an optical approach, thus a general purpose code, the Numerical Electromagnetics Code - Basic Scattering Code, was chosen as the computational tool. This code is based on the modern Geometrical Theory of Diffraction and allows computation of scattering of bodies composed of canonical shapes such as plates and elliptic cylinders.

Apertures mounted on a curved surface (the SRB) cannot be accommodated by the code, so an antenna model consisting of wires was devised that approximated the actual performance of the antennas. Although the method of moments (MM) was not used in developing the antenna model, the code's MM input option proved instrumental in implementing the scheme. The improvised antenna model matched well with measurements taken at the NASA/Marshall Space Flight Center (MSFC) range. The SRB's, the external tank, and the shuttle nose were modeled as circular cylinders, and the code was able to produce what is thought to be a reasonable roll-plane pattern.
[Vol. 5, No. 1 (1990)]

AN ALTERNATIVE DESCRIPTION OF THE MAGNETIC CURRENT ANNULAR RING (FRILL) SOURCE

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An alternative method is presented of considering, and of deriving expressions for the fields generated by, an annular ring of magnetic current (magnetic frill source). The magnetic frill appears to offer a means of numerical model excitation that is more realistic than the pulse source and, moreover, provides analytical expressions for fields in some cases. The fields for the magnetic frill source were first derived by Tsai from the electric vector potential produced by the magnetic current. The method described shows the source to resemble a toroidal transformer and the field expressions are derived from the magnetic vector potential produced by electric currents. The expressions derived are, in essence, the same as those of Tsai, but it is considered that the method yields greater physical insight into the source and so facilitates modification to suit particular applications. Tsai's expression which is of most interest for numerical calculations is derived by inspection using the method described. For calculations using point matching however, the benefits of using the frill source seem more apparent than real. **[Vol. 5, No. 1 (1990)]**

BICONICAL TRANSMITTING ANTENNAS, A NUMERICAL ANALYSIS

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We have obtained a general, numerical solution of an ideal biconical transmitting antenna, with arbitrary arm length and conic angle. We evaluate all necessary spherical functions, including Legendre functions of integer and noninteger degrees, and spherical Hankel functions of integer degrees. Using Schelkunoff's solution, field coefficients appear as an infinite set of unknowns that satisfy a linear equation. We truncate the infinite set at 16; for a 5^{o} antenna the Legendre functions have maximum degree 33.3 in the interior region and 31 in the exterior region. To minimize the error, we discard the last two terms in all field, power, and impedance calculations. Solutions are checked in several ways for consistency, including evaluating and comparing calculated fields across the antenna aperture. Results obtained are input impedance, radiation pattern, all fields including near and far ones, and antenna surface current and charge density. Representative plots of all results are included. **[Vol. 5, No. 1 (1990)]**

USING NONUNIFORM SEGMENTS LENGTHS WITH NEC TO ANALYZE ELECTRICALLY LONG WIRE ANTENNAS

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In this paper an electrically long monopole is analyzed using the Numerical Electromagnetics Code, version two (NEC-2). Due to the electrical length of the monopole and the segment length requirement established for the NEC-2 program, the computer memory requirement and computational time become excessive. By successively increasing the segment length with distance from the source, very large structures can be analyzed accurately and efficiently. Various schemes for selecting the segment lengths are considered, and the results are compared to those obtained by using a large number of electrically short segments. This technique of grading segment lengths allows one to employ NEC-2 to analyze other electrically long wire antennas. **[Vol. 5, No. 2 (1990)]**

VERIFYING WIRE-GRID MODEL INTEGRITY WITH PROGRAM 'CHECK'

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A wire-grid model of a complex surface such as an aircraft consists of hundreds of "vertex" points joined by hundreds of wires or "links". A wire antenna analysis program such as NEC is used to find the currents on the wires. The formulation within NEC imposes restrictions on the geometry of the wires, which limit the length of "segments" compared to the wavelength, the radius compared to the wavelength, the ratio of the segment length to the radius, and so forth. This paper collects these limitations together into a set of "modeling guidelines". The "integrity" of a wire-grid is its ability to

represent the electrical behaviour of the continuous surface that it models. An important aspect of integrity is conformance to the "modeling guidelines". Gross errors creep into complex grids: repeated wires, omitted wires, wires of zero length. More subtle errors which violate the "modeling guidelines" can lead to incorrect current distributions and misleading radiated or scattered fields form the wire-grid when solved with the NEC code.

This paper describes a program called CHECK which examines an input geometry file for the NEC program for conformance to the "modeling guidelines" by each individual wire, by wires forming junctions, and by pairs which do not join but are closely spaced. CHECK tabulates "notes", "warnings" and "errors" to aid the user in assessing the degree to which the model satisfies the guidelines. CHECK systematically finds all the guideline violations in a model. CHECK produces lists of wires for display with computer graphics to show the location of each type of problem that CHECK finds. The guideline violations found by CHECK inherently suggest improvements that can be made to the wire-grid. **[Vol. 5, No. 2 (1990)]**

SELECTING WIRE RADIUS FOR GRID/MESH MODELS

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Conducting bodies such as antennas and scatterers can be modelled by thin wire segments. However, a generally accepted and consistent criteria for selecting optimum radius for the wire segments in the model has yet to be specified. This paper presents some results from modelling microstrip patch antennas with thin wires and the effects of wire radius on the resonance characteristics of the antenna. **[Vol. 5, No. 2 (1990)]**

PILGRIMS PROGRESS - LEARNING TO USE THE NUMERICAL ELECTROMAGNETICS CODE (NEC) TO CALCULATE MAGNETIC FIELD STRENGTH CLOSE TO A SOMMERFELD GROUND

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This paper gives the history and a description of work performed by the authors to identify some errors and solve some problems involved in the use of the Numerical Electromagnetics Code (NEC2 and NEC3, with the companion code SOMNEC) to calculate H-fields in the vicinity of a Sommerfeld ground, and describes some of the code errors and omissions that have been identified to date. The most significant discovery has been that a section of code has been omitted from the subroutine NHFLD in NEC2, which results in incorrect calculations by NEC2 of near H-field strengths close to a real ground. It must be noted that Macfarlane, Fleming, and Iskra, have access to NEC2 only, whilst Haack has access to both NEC2 and NEC3. **[Vol. 5, No. 2 (1990)]**

ADAPTING THE NUMERICAL ELECTROMAGNETICS CODE TO RUN IN PARALLEL ON A NETWORK OF TRANSPUTERS

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The Numerical Electromagnetics Code (NEC) has been adapted to run in parallel on a 16 transputer PARSYTEC machine. The modification of the code involved the manipulation of the Fortran source code and the development of parallel algorithms to fill and factor the matrix. The performance of the parallel NEC improved as the number of segments used in the simulation increased. When simulating a model with 300 segments the time taken was 45 seconds which is 13.3 times faster than using one processor. **[Vol. 5, No. 2 (1990)]**

THE APPLICATION OF NESTED DISSECTION TO THE SOLUTION OF A 2.5D ELECTROMAGNETIC PROBLEM

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We use the method of nested dissection to solve a 2.5D finite difference electromagnetic problem. This method is considered in some detail, and we have found that the expected theoretical run time savings over more common methods are realised in practice. The program has been used to model EM propagation in coal seams with a view to detecting seam disruptions, which can cause a loss of production in longwall mining operations. Various experimental results and a field survey are discussed and we are able to use these results to construct a physically reasonable model which explains the field data. Some further realistic geological structures are modelled and a comparison between our modelling program and several independent methods shows satisfactory agreement. **[Vol. 5, No. 2 (1990)]**

GTD, PO, PTD, AND GAUSSIAN BEAM DIFFRACTION ANALYSIS TECHNIQUES APPLIED TO REFLECTOR ANTENNAS

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Several available diffraction analyses techniques are compared in this paper. Techniques including GTD, PO, PTD, and Gaussian Beams, are used to analyze representative reflector antenna geometries. First the techniques are compared for a flat circular disc, representing an unfocused system. Next, the techniques are applied to offset ellipsoidal reflectors and the offset parabolic reflectors. Near-fields, focal-fields and far-fields are determined using these techniques. Both co-polar and cross-polar fields are compared. The acceptability ranges of each technique is carefully investigated. Numerical data are presented for representative configurations and, in particular, field

intensities are determined for high power microwave applications. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

MODERN HIGH FREQUENCY TECHNIQUES FOR RCS COMPUTATION; A COMPARATIVE ANALYSIS

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In this article, a comparative analysis is given of various asymptotic high frequency methods for the computation of the Radar Cross Section (RCS) of complex targets. After a brief revue of their principle, the limitations of the most popular methods and of their recent developments: Physical Optics (PO), Physical Theory of Diffraction (PTD), Geometrical Theory of Diffraction (GTD), Uniform Theory of Diffraction (UTD) and PTD extended to creeping waves, are analysed in relation with their theoretical foundations and the critical aspects of their application to the computation of RCS are discussed and illustrated by some numerical examples. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

A HYBRID UTD-EIGENFUNCTION METHOD FOR SCATTERING BY A VERTEX

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Present solutions for the electromagnetic scattering by a vertex are either approximate or difficult to use for computations. For example, GTD (UTD) solutions for vertex scattering are not yet fully developed. The exact eigenfunction solution is both difficult to use and computationally inefficient due to the large number of eigenfunctions that must be retained.

In this work, we obtain the scattering by a vertex (e.g., a quarter plane) by employing the exact eigenfunction solution only in a very small region close to the tip of the vertex. Thus, only a small number of eigenfunctions (e.g., two or three) are required to obtain the current in the tip region. Outside of this region, the UTD is employed to obtain the current. The changeover point is determined by finding the point where the eigenfunction current has decayed to that predicted by UTD wedge and vertex diffraction theory.

Results will be shown for the scattered field from the plane angular sector. In addition, the field scattered by a rectangular plane using this method will be compared with that predicted by the UTD with vertex diffraction, and the results will be seen to be in very close agreement. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

CALCULATION OF ANTENNA PERFORMANCE USING A HYBRID TECHNIQUE WHICH COMBINES THE MOMENT METHOD WITH AN ASYMPTOTIC CURRENT

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Previously, this hybrid technique, a hybrid theory of diffraction, which combines the moment method with an asymptotic current, was used by Kim and Thiele to solve several 2-dimensional and 3-dimensional scattering problems when the incident field was a plane wave. In this paper the method is extended to problems in which the incident field is the near field of an antenna and also extended to calculate antenna impedance. As a sample problem, a monopole at the center of a circular disk is considered. Since the general procedure is an iterative one, the starting point in this problem is the assumption of the current distribution on the monopole. This current distribution generates the initial incident field which in turn gives the initial value of the asymptotic current on the circular disk (which is similar to the geometrical optics current).

The current in the asymptotic region (i.e., away from the edge of the disk), which is dominated by the optics type current on the entire surface of the scatterer, is solved by an iterative method to give the approximate surface current using the magnetic field integral equation. The difference between the approximate and true surface currents is calculated from the moment method current, which exists near shadow boundaries and/or sharp discontinuities in geometry. That is, the moment method current induces a current in the asymptotic region which is the difference between the optics type current and the true current.

The impedance may be calculated by using the infinite ground plane value plus the change caused by the finite extent of the ground plane through the use of equivalent currents.

Results are shown for both the impedance and the radiation patterns. These results are compared with other known results and the agreement is seen to be very good for both large (e.g., ka > 6) and small (e.g., ka < 3) ground planes. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

ANALYSIS AND SIMULATION OF COLLISION AVOIDANCE TCAS ANTENNAS MOUNTED ON AIRCRAFT

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Traffic-alert and Collision Avoidance systems (TCAS) are being developed by order of the Federal Aviation Administration (FAA) to assist aircraft pilots in mid-air collision avoidance. This paper discusses computer models developed to simulate the radiation patterns of TCAS arrays mounted on the fuselage of any aircraft. Computer models are also used to calculate and evaluate the errors in estimating the bearing of aircraft in the vicinity of a TCAS-equipped airplane. The performance of two TCAS systems mounted on a Boeing 737 aircraft are studied and compared. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

NUMERICAL TECHNIQUES TO DETERMINE THE UTD BISTATIC CREEPING WAVE PATHS AND PARAMETERS FOR AN ELLIPSOID

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In applying the Uniform Geometrical Theory of Diffraction (UTD) to evaluate the scattering patterns of a doubly curved surface, the determination of correct ray paths is one of the most important and difficult tasks. In this paper, an efficient numerical technique to obtain the complete ray path of the creeping wave for the bistatic scattering of an ellipsoid is discussed. Also, the numerical method to evaluate the energy spreading factor of the creeping wave and the caustic distance at the diffraction (launching) point are described. An ellipsoid is chosen because of its modeling capability to represent the fuselage of an aircraft and similar objects. The same numerical techniques for an ellipsoid can be extended to a general doubly curved surface as well. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

DESCRIPTION OF A RADAR CROSS SECTION PREDICTION CODE WITH APPLICATIONS TO INDUSTRIAL PROBLEMS

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Following the recent advances in the fields of electromagnetic prediction theory and computer power, and a growing interest to low observables or stealth platforms [1], new software tools for the calculation of radar backscattering have been developed in several companies/institutions. While the basics of the algorithms used are the same, each code has been focused on different ranges of frequencies, kinds of platforms, and so on. This paper describes the prediction code developed at IDS, which is currently used in consultancy activities in the fields of design of new platforms with reduced/controlled RCS, as well as evaluation of the radar signature of existing systems. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

NUMERICAL MODEL OF MICROWAVE BACKSCATTERING AND EMISSION FROM TERRAIN COVERED WITH VEGETATION

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ITALY

A computational model for estimating microwave scattering and emission from the earth's surface covered with vegetation (MESCAM) has been developed. The model is founded on relevant electromagnetic properties of the vegetation and of the underlying terrain and takes into account multiple scattering both within the vegetation and between vegetation and underlying soil. By selecting the appropriate scattering functions, the backscattering coefficient and the emissivity can be estimated in a wide range of frequencies, for different sensor configurations, and for a variety of terrain and vegetation characteristics. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

ANALYTIC RAY TRACING FOR THE STUDY OF HF MAGNETO-IONIC RADIO PROPAGATION IN THE IONOSPHERE

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Monash University
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AUSTRALIA

J. Chen, P. L. Dyson
Department of Physics
Latrobe University
Bundoora, Vic. 3083
AUSTRALIA

Ray tracing provides a quantitative tool for the study of HF radio wave propagation in the ionosphere, but its use is limited in many applications by the time required to numerically trace many separate rays. One approach to overcoming this problem is the use of ionospheric models that admit analytic solutions of the ray tracing equations. Such a model may be based on a vertical plasma frequency profile consisting of what are known as quasi-parabolic segments. Analytic tracing is much faster than numerical tracing (from 5 to 10 times), but more limited in the range of situations that can be considered.

The main thrust of the paper is to present and test a technique, based on the use of an equivalent operating frequency, that allows the analytic results to be extended to take approximate account of the magneto-ionic effects associated with the earth's magnetic field. Errors in group path, phase path and ground range are generally less than 5 km, errors in absorption generally less than 5%. **[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]**

ABOUT THE STUDY IN THE TIME DOMAIN OF JUNCTIONS BETWEEN THIN WIRES

Amelia Rubio Bretones, Alfonso Salinas Extremera,
Rafael Gómez Martín, Jesús Fornieles Callejón
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Facultad de Ciencias
Universidad de Granada
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SPAIN

DOTIG1 is a computer code developed for the study of the interaction of arbitrary electromagnetic signals with thin-wire structures, in the time domain. It calculates the current distribution induced on the structure by solving the electric field integral equation using the moment method. The numerical procedure used to develop the program and different possibilities for treating junctions are briefly described.

To obtain an accurate solution for the current induced on the thin-wire structures it is very important to pay attention to the zones at which the wires intersect. Thus, different junction treatments were tested for several simple structures. Following some convergence criteria the current distributions were compared to a reference solution and also, by way of Fourier transform, with results obtained using some well known frequency-domain codes. **[Vol. 6, No. 2 (1991)]**

OPTIMAL LOCATION FOR MATCHING POINTS FOR WIRE MODELLING WITH MMP

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It is a basic premise in electromagnetic field modelling that the tangential electromagnetic field on the surface of ideal conductors must vanish. When point matching is used to impose this condition,

the location of the matching points must be chosen. This paper treats the special case of thin wires. It is shown that for common approximations of the wire currents, the optimum locations of the matching points are well defined and that forcing the boundary condition beside these well defined matching points would increase the errors. For both piecewise-linear and staircase approximation of the current, explicit formulae for the optimum location of the matching points are given. **[Vol. 6, No. 2 (1991)]**

SURFACE MODELLING FOR EM INTERACTION ANALYSIS

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CANADA

This paper deals with the numerical modelling of the surface of a structure with a wire grid or a surface patch for Electromagnetic (EM) interaction analysis. Surface currents and fields on a wire grid model are computed using the Numerical Electromagnetics Code (NEC). The results are compared with those obtained on a triangular surface patch model using an Electric Field Integral Equation (EFIE) formulation. Simple structures such as a square plate as well as complicated structures such as an aircraft are considered. Good agreement is obtained in most cases. **[Vol. 6, No. 2 (1991)]**

ON THE FUNCTIONING OF A HELICOPTER-BORNE HF LOOP ANTENNA

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SOUTH AFRICA

Numerical techniques allow engineers to evaluate the performance of antennas on complex structures. These techniques can provide valuable physical insights into the overall functional performance of such antennas. This short paper reports on the use of NEC2 to investigate the radiation characteristics of a loop antenna mounted below the tailboom of a helicopter in the frequency band 2-15 MHz. It was concluded that such a loop antenna serves mainly to excite a dominant electrical dipole mode of operation for frequencies less than the lowest natural electrical resonance frequency of the helicopter itself, but greater than some frequency near the low end of the HF band. A limited set of measurements performed on a scale model of a helicopter generally supports the conclusions drawn from the numerical results predicted using NEC2. The reported result is of importance in so-called 'nap-of-the-earth' HF communications from helicopters. **[Vol. 6, No. 2 (1991)]**

THE LINEAR-PHASE TRIANGULAR FACET APPROXIMATION IN PHYSICAL OPTICS ANALYSIS OF REFLECTOR ANTENNAS

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Numerical analysis of reflector antennas uses a discrete approximation of the radiation integral. The calculation replaces the actual reflector surface with a triangular facet representation. The physical optics current is then approximated within each facet. This paper provides analytical details of the method based on the assumption of a constant magnitude and linear-phase approximation of the physical optics current. Example calculations are provided for parabolic, elliptical, and shaped subreflectors. The computed results are compared with calculations made using a constant-phase approximation. These results show that the linear-phase approximation is a significant improvement over the constant-phase approximation in that the solution converges over a larger angular region of space. This improvement can significantly reduce storage requirements and possibly execution speed. **[Vol. 6, No. 2 (1991)]**

SIMPLIFIED 3-D MESH GENERATOR

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UNITED KINGDOM

Wire-grid modelling of continuous surfaces for structures in three dimensions is a tedious and time consuming process. This paper describes a simplified automatic mesh generator that converts a large class of three-dimensional structures into appropriate wire-grid models. The output of the generator can readily be used as the input to wire antenna Moment Method codes. It is however designed specifically for use with the Numerical Electromagnetics Code (NEC). **[Vol. 6, No. 2 (1991)]**

THE SHORT FAT DIPOLE DEVELOPMENT IN APL OF A MOM SOLUTION

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USA

This paper describes an effort to find the best profile for a figure-of-revolution, center-fed, electrically-small dipole. It includes presentations on equation development, singularity treatment, code development, verification, and performance. **[Vol. 6, No. 2 (1991)]**

ANALYSIS OF THREE DIMENSIONAL DIELECTRIC LOADED CAVITIES WITH EDGE ELEMENTS

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In this paper we show that edge elements (a class of mixed finite elements) provide an efficient numerical approach in the determination of resonant modes in three dimensional high frequency cavities. These finite elements avoid "spurious modes", the non-physical numerical fields obtained from the solution of eigenvalue problems.

Here, empty cavities as well as dielectric loaded cavities are analyzed: no "spurious mode" was observed. Moreover, comparisons with analytical results and previously published ones show the great accuracy of the numerical technique. **[Vol. 6, No. 2 (1991)]**

ANTENNA ARRAY MODELLING BY PARALLEL PROCESSOR FARMS

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UNITED KINGDOM

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The fast concurrent implementation of a FORTRAN method of moments analysis of the electromagnetic properties of an array of tapered slot antennae is discussed. Decomposition of an existing FORTRAN algorithm for calculation of the currents induced by an incident radiation field in an infinite array of tapered slot antennae is described. The problem was distributed across an array of INMOS transputers, yielding significant speed-up over a single CPU. This decomposition was relatively simple to implement, can readily be scaled to larger processor arrays virtually indefinitely, and promises linear speed-up with the number of processors in the array. **[Vol. 6, No. 2 (1991)]**

PAPERS WITHOUT ABSTRACTS[1]

BROADCAST ANTENNA OPTIMIZATION WITH MICROCOMPUTERS

P. M. Hansen, J. W. Rockway
Naval Ocean Systems Center
San Diego, CA 92152-5000
USA

[Vol. 1, No. 1 (1986)]

MODELING MONOPOLES ON RADIAL-WIRE GROUND SCREENS

Gerald J. Burke
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Livermore, CA 94550
USA

[Vol. 1, No. 1 (1986)]

A NEC TOPSIDE ANTENNA CASE STUDY WITH DIDEC AND SPECTRUM: MODEL GENERATION AND CURRENT DISPLAY CODES

S. J. Kubina, Colin Larose
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7141 Sherbrooke St. W.
Montreal, Qub. H4B 1R6
CANADA

[Vol. 1, No. 2 (1986)]

A VALIDATIVE COMPARISON OF NEC AND MININEC USING NBS EXPERIMENTAL YAGI ANTENNA RESULTS

J. K. Breakall
University of California
Lawrence Livermore National Laboratories
Livermore, CA
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[Vol. 1, No. 2 (1986)]

NEW VERSION OF ESP

E. H. Newman
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ElectroScience Lab
1320 Kinnear Road
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[Vol. 2, No. 1 (1987)]

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[1]In earlier issues, abstracts were not required.

CORRECTIONS TO THE LINVILL NORMALIZATION PROCEDURE IN THE NEC BASIC SCATTERING CODE

Richard D. Albus
IIT Research Institute
Annapolis, MD 21401
USA

[Vol. 3, No. 1 (1988)]

NUMERICAL ELECTROMAGNETICS COMPUTATION USING THE INMOS T800 TRANSPUTER ON AN OLIVETTI M24 PERSONAL COMPUTER

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Department of Electrical and Electronic Engineering
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REPUBLIC OF SOUTH AFRICA

[Vol. 3, No. 2 (1988)]

NUMERICAL INTEGRATION OF MARCUSE'S POWER LOSS FORMULA

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Towson, Maryland
USA

Albert Krall
Advanced Technology and Research Corp.
Laurel, Maryland
USA

Robert H. Baran
U.S. Naval Surface Weapons Center
Silver Spring, Maryland
USA

[Vol. 3, No. 2 (1988)]

PREDICTIONS OF TRANSIENT EDDY CURRENT FIELDS USING SURFACE IMPEDANCES IN SHELL STRUCTURES

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[Vol. 4, No. 1 (1989)]

ANTENNAS ON DIELECTRIC COATED CONVEX SURFACES: THEORY AND EXPERIMENTATION

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[Vol. 6, No. 1 (1991), Special Issue on Applications of High Frequency Methods and Computer Techniques in Electromagnetics]

ANNOUNCEMENTS

CODE USER GROUPS

To provide needed links between developers and users of electromagnetics modeling codes and techniques, ACES has formed several code user groups resulting in the following benefits:

1. Distribution of developer communications (letters, bug reports, and upgrades) to the user group members, so as to provide the developer with a single point-of-contact for as many users as possible.

2. Collection and evaluation of user feedback, with subsequent forwarding to the developer (this includes the compilation of user comments as well as the verification of bug reports. User-proposed "work-arounds" and code modifications can be handled similarly).

3. Periodic surveys of users, to determine the major actual applications of the code, with a survey report sent to the developer.

4. Assistance to inexperienced code users via publication of tutorials, user guidelines, and typical problems with solutions -- and also via increased access to experienced users (This will reduce the number of interruptions which a developer receives form beginners stuck on a problem. Furthermore, such assistance can indirectly enhance the code's marketability).

Some of these benefits to users are contingent upon the cooperation of the respective code developers (and will vary from code to code), whereas other benefits can be provided independently. However, in the interest of serving developers and users alike, ACES is seeking full cooperation from the developers, who are also being encouraged to maintain existing user-support arrangements for non-members of ACES. Information recieved from code developers and users will be distributed to User Group members or published in the *ACES Newsletter*. Contact the Users Groups Chairman:

Russ Taylor
McDonnell Douglas Helicopters 530/B335
5000 East McDowell
Mesa, AZ 80205 USA
Phone: (602)891-5539

BIBLIOGRAPHY OF MEASURED ELECTROMAGNETICS DATA

In support of present code validation efforts and requirements, the ACES Newsletter is compiling a bibliography of measured electromagnetics data. For an example of what is needed, see Jim Logan's contribution (ACES Newsletter, vol. 5, no. 1, March 1990, pp. 14-15). Out interests include all areas of electromagnetics and are not limited to radiation, propagation, and scattering. If you know of any measured data send the appropriate bibliographic information to:

Paul Elliot,
Editor, *ACES Newsletter*
ARCO Power Technologies, Inc.,
1250 24th St. NW, Suite 850
Washington, DC 20037 USA.
Phone: Work: (202)223-8808
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BOOK DISCOUNT FOR ACES MEMBERS

A reduced price on the book *Computational Electromagnetics* (described below) is available to ACES members. Single issues would most likely cost approximately $20 more without this special price. To obtain this special price contact Paul Elliot, *ACES Newsletter* Editor, at the address shown below, by **September 30, 1992**.

Paul Elliot
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COMPUTATIONAL ELECTROMAGNETICS

(Computer Physics Communications, Volume 68, published by North-Holland)

Edited by L. Shafai, The University of Manitoba, Canada

1991 xvi + 498 pages **Special price for ACES members: US $75.00**

Contents: Preface

Integral Operator Methods. An introduction to the method of moments (*E.H. Newman and K. Kingsley*). Electromagnetic coupling through apertures by the generalized admittance approach (*R.F. Harrington and J.R. Mautz*). Using model-based parameter estimation to increase the physical interpretability and numerical efficiency of computational electromagnetics (*E.K. Miller and G.J. Burke*). Hybrid methods in computational electromagnetics: a review (*L.N. Medgysei-Mitschang and D.S. Wang*). Numerical field modelling of objects with edges and corners using a conformal mapping (*H. Moheb and L. Shafai*). Accurage computation of wideband response of electromagnetic systems utilizing narrow-band information (*K. Kottapalli, T.K. Sarkar, R. Adve, Y. Hua, E.K. Miller and G.J. Burke*). Formulations of impedance surfaces coated with dialectric materials (*A.A. Kishk*). The null-field approach to electromagnetic resonance of composite objects (*W. Zheng and S. Strom*).

Differential Operator Methods. Computation of electromagnetic scattering and radiation using a time-domain finite-volume discretization procedure (*A.H. Mohammadian, V. Shankar and W.F. Hall*). Transmission-line matrix (TLM) method for scattering problems (*N.R.S. Simons, A.A. Sebak, E. Bridges and Y.M.M. Antar*). A time-dependent method for the numerical solution of wave equations in electromagnetic scattering problems (*R.T. Ling*). Computational techniques in bioelectromagnetics (*M.F. Iskander*). Coupled finite element and boundary element method in electromagnetics (*G.Y. Delisle, K.L. Wu and J. Litva*).

Analytic and Asymptotic Based Methods. Scattering by systems of spheroids in arbitrary configurations (*M.F.R. Cooray and I.R. Ciric*). The generalized multipole technique (*A.C. Ludwig*). Generalized solutions for electromagnetic scattering by elliptical structures (*A. Sebak and L. Shafai*). Analysis of electromagnetic scattering using a current model method (*Y. Leviatan, A. Boag and A. Boag*). Three-dimensional scalar beam diffraction by a half plane (*G.A. Suedan and E.V. Jull*). Two ray shooting methods for computing the EM scattering by large open-ended cavities (*R.J. Burkholder, R.C. Chou and P.H. Pathak*).

Some Applications to Devices. Finite difference solutions of infinite arrays of two-dimensional microstrip structures (*J.P.R. Bayard and D.H. Schaubert*). A generalized CAD model for printed antennas and arrays with arbitrary multi-layer geometrics (*N.K. Das and D.M. Pozar*). A numerical approach to line antennas printed on dielectric materials (*H. Nakano*). Simulation and analysis of waveguide based optical integrated circuits (*S.T. Chu, W.P. Huang and S.K. Chaudhuri*). Analysis of circular patch antennas on electrically thick substrates (*A.K. Bhattacharyya*). Author index.

FIRST ANNOUNCEMENT AND CALL FOR PAPERS

BECAUSE EUROPEAN WORKSHOP

(BEnchmark of Concurrent Architectures for their Use in Scientific Engineering)

INRIA Sophia-Antipolis (FRANCE)
October 13-16, 1992

Organized by BECAUSE Consortium and INRIA
(ESPRIT Project 5417)

Scientific Committee:

A. AGG	Smith Associates, UK
E. Banos Ayuso	Ingeciber SA, Spain
C. Bryant	Oxford, UK
M. Delves	University of Liverpool, UK
A. Dervieux and L. Fezoui	Inria-Sophia Antipolis, France
C. Farhat	University of Boulder, Colorado, USA
C. Greenough	Rutherford Appleton Laboratory, SERC, UK
T. Kalamboukis	Athens University of Economics, Greece
P. Leca	Onera, France
K. Schleisiek-Kern	Delta-T gmbh, Germany
C.W. Trowbridge	Vector Fields, UK
D.M. Watson	Parsys Ltd., UK
E. Znaty and R. Cornubert	Bertin & Cie, France

Purpose of the Workshop:

The aim of the Workshop is to gather researchers and engineers that want to apply scientific computation, with an emphasis on Continuum Mechanics (Fluid Mechanics, Electromagnetism, Semi-conductor simulation...) in order to study and compare the different means to be used for a more efficient parallel calculation: hardware, languages, environment and software tools are to be considered together with new numerical parallel algorithms. Progress and new developments will be reviewed during the conference.

This workshop will focus on parallel architectures from the distributed memory computer type (SIMD and MIMD) but shared memory machines will be considered too.

Format of the Workshop:

The workshop will consist of invited lecturers, panel sessions, working groups and a limited number of selected contributions which must involve some mandatory test cases:

- assembly loops on structured or unstructured grids
- linear resolution of sparse matrix systems
- FFT

Potential contributors may ask for test programs and for further information at the following address:

Dr. L. FEZOUI
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2004 Route des Lucioles, B.P. 109
06561 VALBONNE CEDEX (FRANCE)
e-mail:fezoui@cosinus.inria.fr

INTERNATIONAL WORKSHOP
on
APPLIED COMPUTATIONAL ELECTROMAGNETICS

DIRECTIONS FOR THE NINETIES
at
Telecom Australia Research Laboratories
Clayton Victoria Australia

14 AUGUST 1992

Historically the application of computational methods in electromagnetics has been centered upon scatterer and antenna modelling using moment methods, as well as high-and- low frequency computational techniques. These methods have enabled metallic structures of widely varying geometry, and interactions with media and materials such as ground planes to be analyzed. The major beneficiaries have been the defence and communications industries, and progress in these areas would not have been possible without the computational skills presently available. The application of finite element, finite difference and finite difference time-domain methods has become of particular interest within the professional EM community, since these tools allow the modelling of more complex problems such as the design of generators and motors, the response of biological tissues to electromagnetic radiation, and the analysis of modern structures with composite materials.

This Workshop is intended to be a timely survey of computational efforts in code development and application, matched to present and emerging needs to the end of the decade. It is sponsored jointly by Telecom Australia Research Laboratories, ACES, the IEEE Victoria Section, and the Defence Science and Technology Organization. The Workshop format will include presentations by eminent speakers, audience participation, and specialized software demonstrations.

Among the invited speakers will be Prof. Tapan Sarkar, Dr. Edmund Miller, Mr. Gerry Burke, Prof. Bach Anderson, and others. This will be an excellent opportunity to benefit from their experience and insight, to discuss your applications and to become aware of available codes.

The Workshop has been scheduled between the Asia-Pacific Microwave Conference in Adelaide (11-13 Aug) and the URSI Electromagnetic Theory Symposium in Sydney (17-20 Aug). Arrangements are being made with travel agencies for special fares for parts or all of the circuit for visitors to Australia.

For additional information contact:

Tony Fleming
ACES International Workshop Chairman
Telecom Australia Research Laboratories
770 Blackburn Road
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Telephone: +61-3-541-6155
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Message from the 1993 Symposium Chairman

9th Annual Review of Progress in Applied Computational Electromagnetics

On behalf of the Applied Computational Electromagnetics Society, special thanks are extended to Pat Foster for her outstanding work with the 1992 Symposium. Congratulations to Pat for a job well done.

In 1991 and 1992, the Conference *Proceedings* were published in time for distribution at the conference. While this practice results in a tight time schedule for processing the Technical Program papers, it has been overwhelmingly endorsed as the preferred mode of operation. Preconference publication is now the established practice. To defray the high cost of preconference publication, the ACES Board of Directors has approved a requirement for one non–refundable registration fee to accompany each final camera–ready paper which is submitted for inclusion in the *Proceedings.* This policy begins with the 1993 Symposium.

A growing participation in the ACES Review of Progress Symposium from outside North America was particularly evident in 1992, with a strong European representation. This expanded participation resulted in very positive contributions to the 1992 Symposium, and we hope this international activity will continue to increase in 1993.

An innovation to the Technical Program in 1992 was parallel events running on Tuesday afternoon. While the idea was initially greeted with some skepticism, it was well received in the final analysis and enabled holding the technical paper sessions to three days (Tuesday through Thursday). It appears that a clear majority of registrants prefer having a three–day format for the technical papers, and we will endeavor to honor that sentiment in the 1993 Symposium program.

The NSF/IEEE Center for Computer Applications in Electromagnetics Education (CAEME) has been an active participant in the Symposium for several years now, and a CAEME session is expected in 1993. In addition to session presentations, it is anticipated that individuals who have developed educational EM software will be giving live demonstrations of their capabilities and latest developments.

Dr. John Rockway organized an excellent slate of short courses on timely topics in 1992. These included time domain modeling, GEMACS, electromagnetic microwave design, FDTD, signal representation and model–based parameter estimation applications in computational EM, antenna radiation in natural environments, UTD, and the 3D MMP code. Because the short courses can be such a valuable resource and service, the slate of short course topics will receive careful consideration for 1993. Special requests for short course topics are welcome, and now is the time to make your needs known.

Dr. Andy Terzouli of the Air Force Institute of Technology is Co–Chairman for the 9th Annual Review of Progress in Applied Computational Electromagnetics, and Andy will then be 1994 Symposium Chairman. The practice of having a Co–Chairman was initiated in 1992, and it appears that the resulting year–to–year continuity will be helpful for maintaining high quality in future Symposia.

Any suggestions for special session topics, short courses, etc., should be forwarded to the Symposium Chairman as soon as possible. A broad base of involvement can serve to further improve the Symposium, and constructive inputs on any facet of the 9th Annual Review of Progress in Applied Computational Electromagnetics are both welcome and invited.

Finally, as you plan ahead for 1993, I hope you will give high priority to joining your friends and colleagues in Monterey the week of March 22–26!

Perry Wheless
1993 Symposium Chairman

1993 CALL FOR PAPERS 1993

The 9th Annual Review of Progress in Applied Computational Electromagnetics

March 22–26, 1993
Naval Postgraduate School, Monterey, California

Share your knowledge and expertise with your colleagues
at the Applied Computational Electromagnetics Society's
9th Annual Review of Progress

The Annual ACES Symposium is an ideal opportunity to participate in a large gathering of EM Analysis enthusiasts. Whether your interest is to learn or to share your knowledge, this symposium is aimed at you. In addition to technical paper sessions, the Symposium includes live demonstrations, exhibits, and short courses. All aspects of computational electromagnetic analysis will be represented but particular emphasis at the 1993 Symposium will be placed on applications of numerical methods, especially those validated by experiment. The Technical Program will feature numerical methods in electromagnetics used to treat real life applications.

The 1993 Annual Review of Progress in Applied Computational Electromagnetics will be the ninth yearly Symposium to bring analysts together to share information and experience about the practical application of EM analysis using computational methods. The ACES Symposium is a highly influential outlet for promoting awareness of recent technical contributions to the advancement of computational electromagnetics. Attendance and professional program paper participation from non–ACES members and from outside North America are encouraged and welcome. The Symposium has four main components: technical paper sessions, short courses, demonstrations, and vendor booths. Contact Perry Wheless for details.

1993 ACES
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1993 ACES Symposium

Sponsored by: ACES, USAIESA, NRaD, NPS, DOE/LLNL, DOD/USA CECOM
In cooperation with: The IEEE Antennas and Propagation Society, the IEEE Electromagnetic Compatibiity Society and USNC/URSI.

1993 CALL FOR PAPERS 1993

The 9th Annual Review of Progress in Applied Computational Electromagnetics

SUBMISSION OF PAPERS

Suggested topics for papers include:

APPLICATIONS	NUMERICAL METHODS	CODE DEVELOPMENT
Antenna Analysis	Differential methods	EM Field Codes
EMC/EMI	Integral methods	NEC
EMP, shielding, radiation effects	Method of Moments	GEMACS
Impulse and transient analysis	Finite Element methods	System Compatibility Codes
Propagation and Scattering	Finite Difference methods	IEMCAP
Microwave, mm-wave components	GTD and FTD methods	SEMCAP
EM machines and devices	Spectral Domain techniques	AAPG
Power Transmission	Low/high frequency issues	COEDS
Accelerator design	Time Domain techniques	Time Domain Codes
Biological applications	Hybrid techniques	Code Validation
Data interpretation	Perturbation multi-pole methods	CAD/automesh genera
Code studies of basic Physics	New algorithms	Graphical I/O Techniques

TIMETABLE

October 1, 1992	Summary Submission Submit four (4) copies of a 300–500 word summary to the Symposium Chairman.
November 17, 1992	Authors notified of acceptance.
January 15, 1993	Submission deadline for camera–ready copy, not more than eight (8) pages including all figures. All submissions become the property of the SYMPOSIUM and will not be returned. The author of each paper accepted for publication will be required to provide Copyright Releases from the author and the sponsoring organization to the Symposium. Copyright Release forms will be supplied at time of acceptance. The author and sponsoring organization will retain the right to free use of the copy protected material. For both summary and final paper, please supply the following data for the principal author – full name, address, telephone, and FAX numbers for both work and home.

Projected registration fee per person for the Symposium is $195.00 ($210.00 after March 12, 1993).

SHORT COURSES

Short courses will be offered in conjunction with the Symposium, covering numerical techniques, computational methods, surveys of EM analysis and code usage instruction. It is anticipated that short courses will be conducted principally on Monday, March 22, and Friday, March 26. Fee for a short course is expected to be approximately $80.00 per person for a half–day course and $130.00 for a full day course, if booked before March 5, 1993. Full details of 1993 Symposium short courses will be available by November of 1992.

EXHIBITS

Vendor booths and demonstrations will feature commercial products, computer hardware and software demonstrations, and small company capabilities.

THE BOEING COMPANY'S CONTRIBUTION TO ACES

In 1991, a grant to ACES from the Boeing Company allowed Dr. Mihaela Morega, of the Polytechnic Institute of Bucharest, Romania, to attend the ACES Conference in Monterey to present the paper entitled, "Transient Leakage Field in Transformers with Saturable Core". Dr. Morega also participated in an international forum to discuss electromagnetic developments from various parts of the world and address future trends.

In the following year, the same grant from Boeing, allowed Dr. Yuanren Qiu, of the Jiaotong University of Xi'an, P.R. China, to travel from mainland China to Monterey and present the paper entitled, "The Finite Element Analysis of 50 Cycles Induction Furnace". Both authors are continuing their contributions to ACES. Dr. Qiu with an earlier paper published in the 1991 ACES Conference Proceedings and Dr. Morega with a second paper published in the 1992 Proceedings. Dr. Morega has also submitted the paper, "A Romanian Experience in CAEME", for publication in a special CAEME issue of the ACES Journal.

It is an ACES objective that such initiatives as the Boeing sponsored attendance of these two University Professors to ACES Conferences will encourage others from distant technical institutions to contribute as ACES participants. During the conference, after a lengthy discussion with Dr. Qiu, Boeing engineer Dave Chapman remarked, "the benefit of dialog between electromagneticists from such far ranging geographical locations and of such dissimilar backgrounds is inspiring and well worth the modest contribution on Boeing's part. I hope other companies will consider similar initiatives to stimulate international participation.

As the representatives from each nation of the international ACES community participate in publication of their work and findings, the entire community benefits. In sponsoring international participation ACES and Boeing are continuing the commitment to worldwide progress in computational electromagnetics.

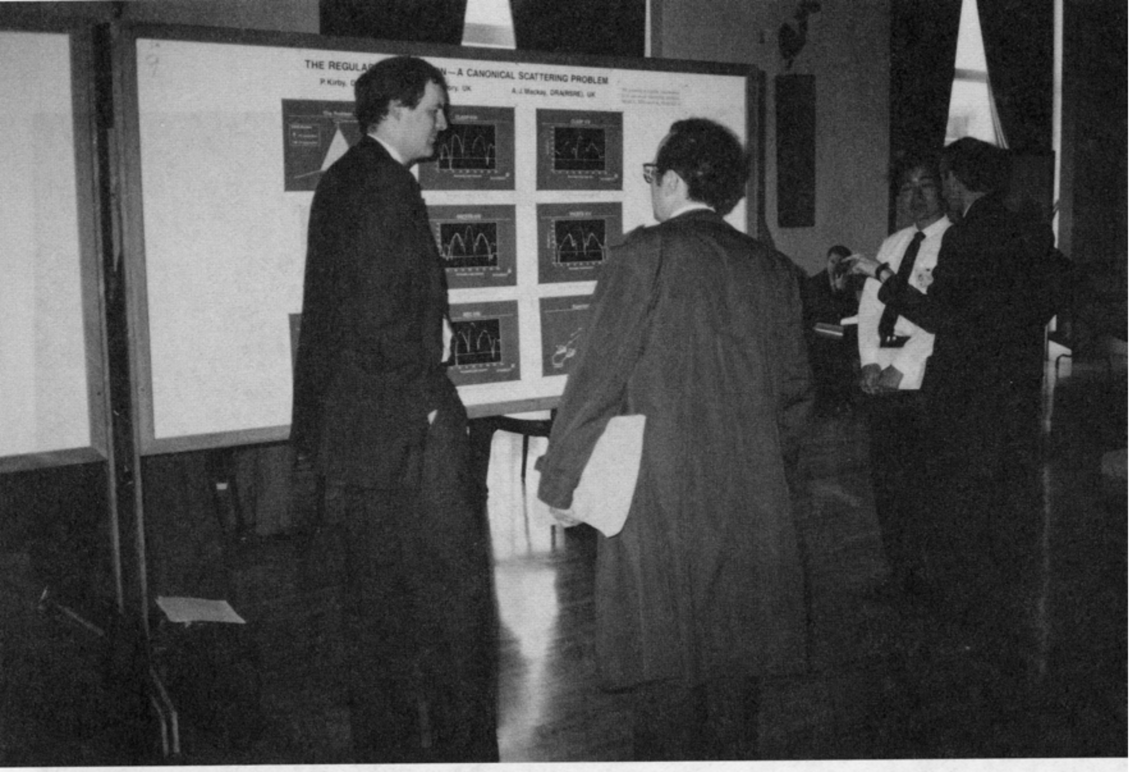
CALL FOR NOMINATIONS

The ACES Nominations Committee is currently accepting nominations for the upcoming Board of Directors Election. All members are encouraged to submit their suggestions to:

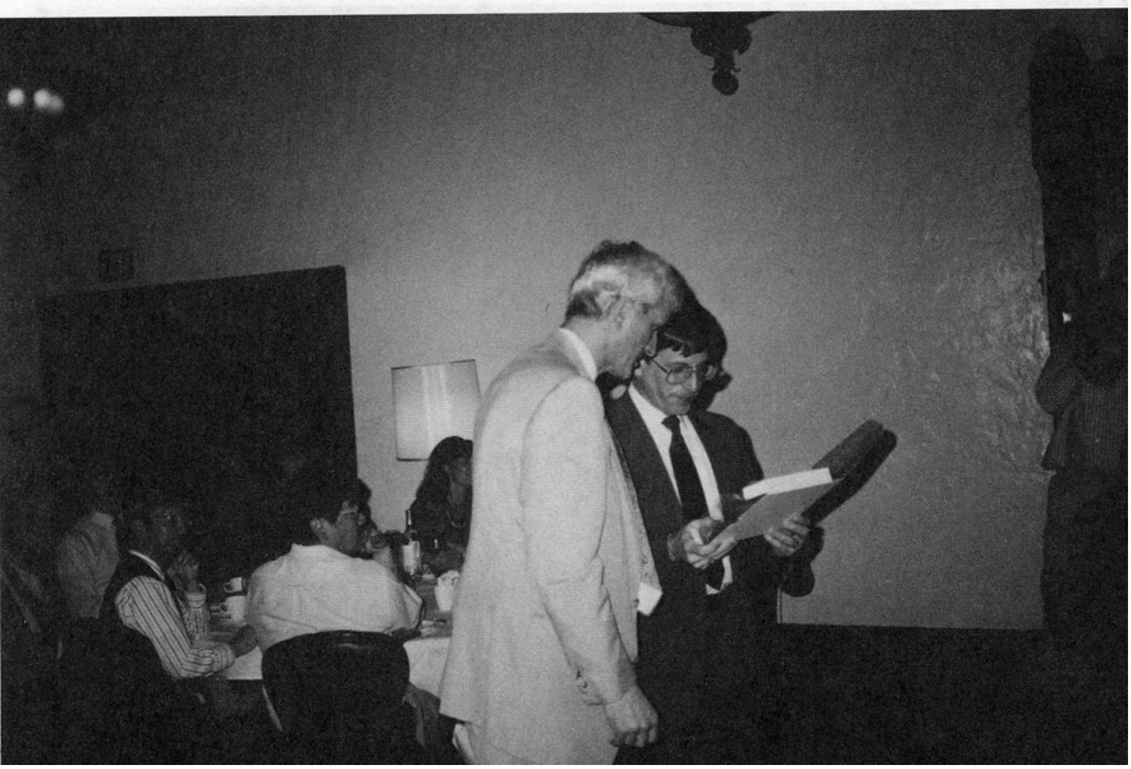
Andrew F. Peterson
School of Electrical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0250
(404) 853-9831 (phone)
(404) 853-9171 (FAX)
ap16@prism.gatech.edu (e-mail)

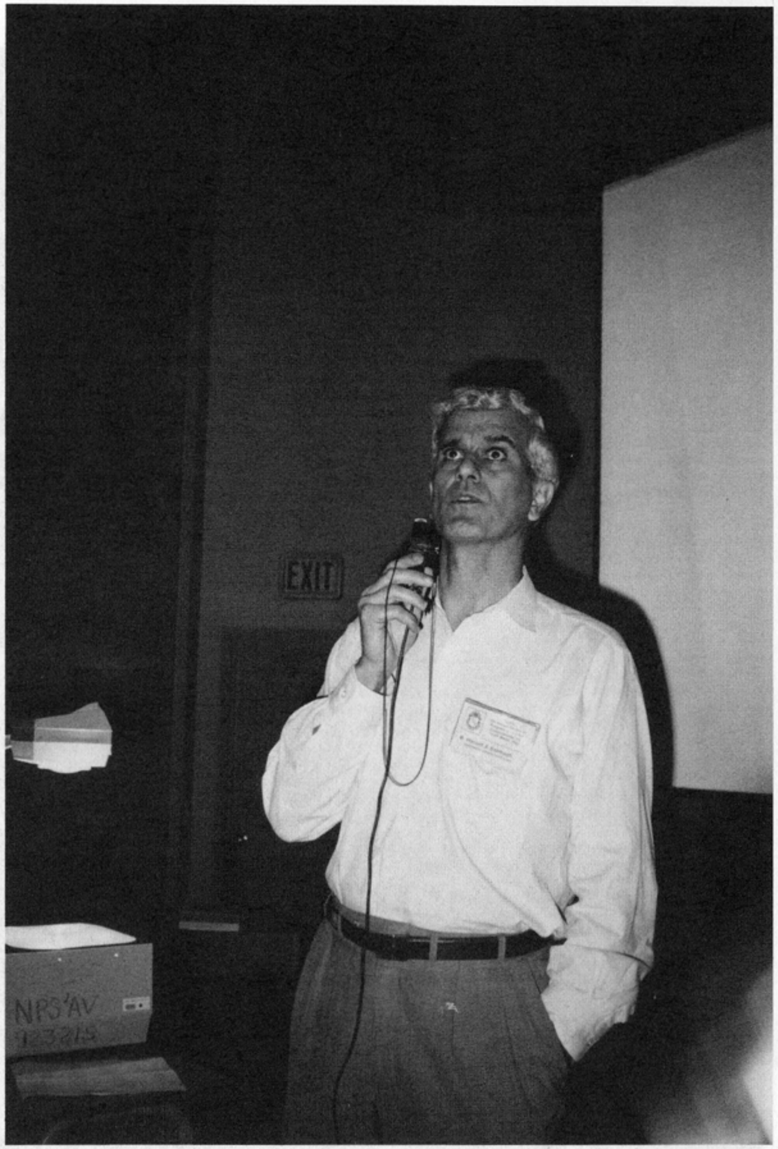
prior to October 1, 1992. The Committee expects to select a slate of approximately six candidates from the pool of suggested nominees. Please be aware that nominees must be members of ACES.

Pat Foster says, "You shouldn't have"

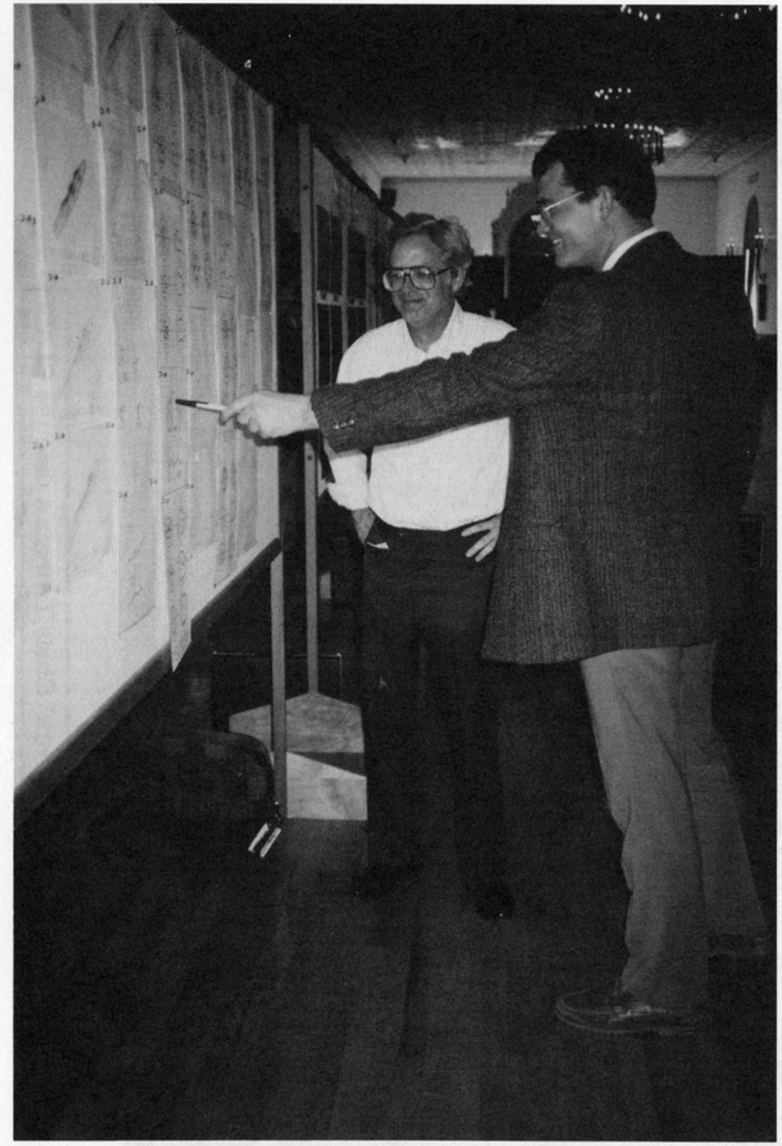


David Lizius and Chris Trueman discuss CLASP



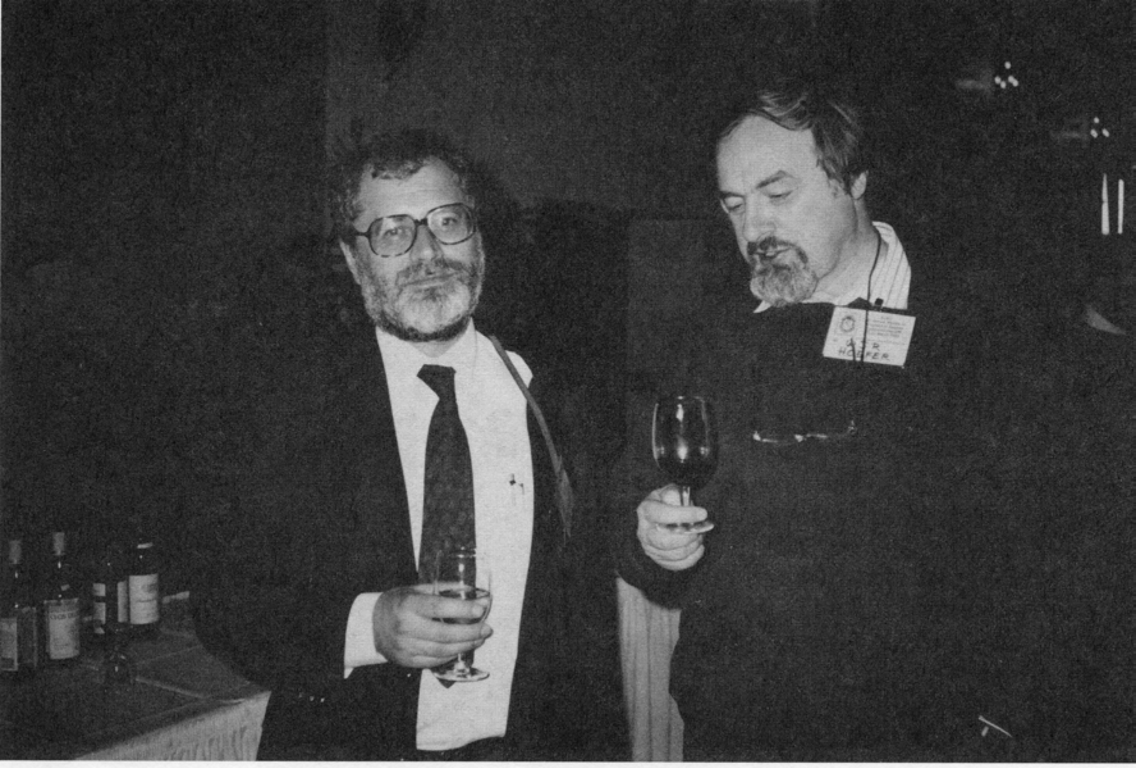


Our New President Hal Sabbagh looks ahead

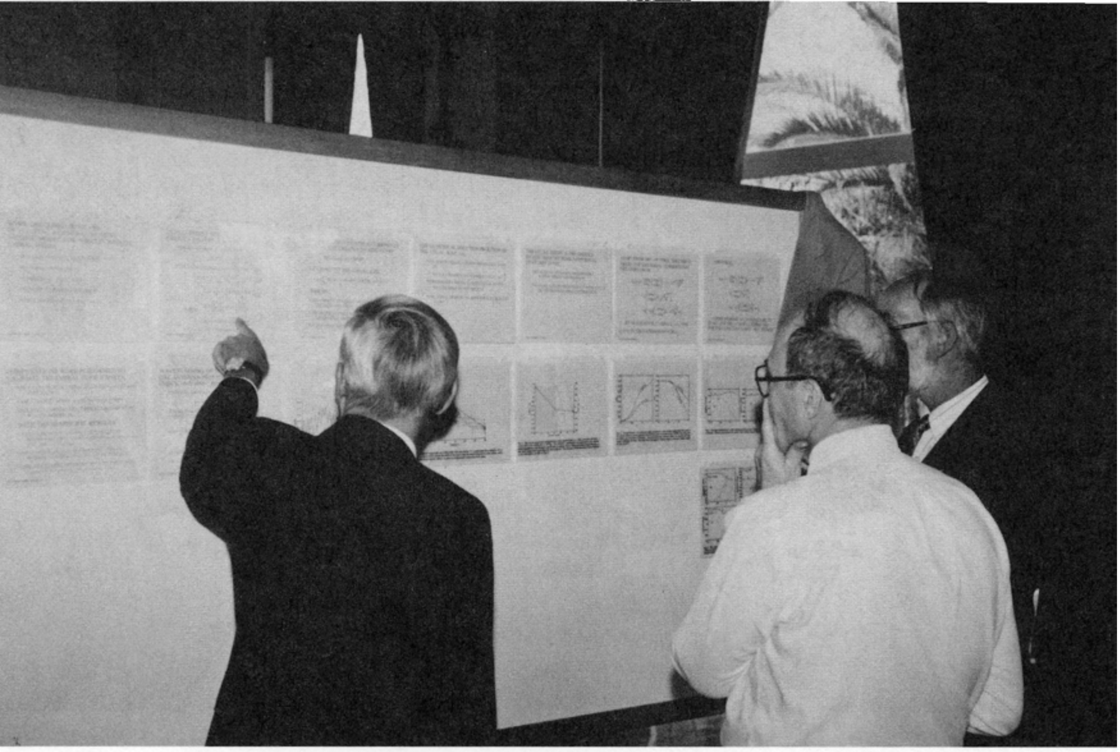


Jay Rockway and Jim McLachlan discuss the model of ships

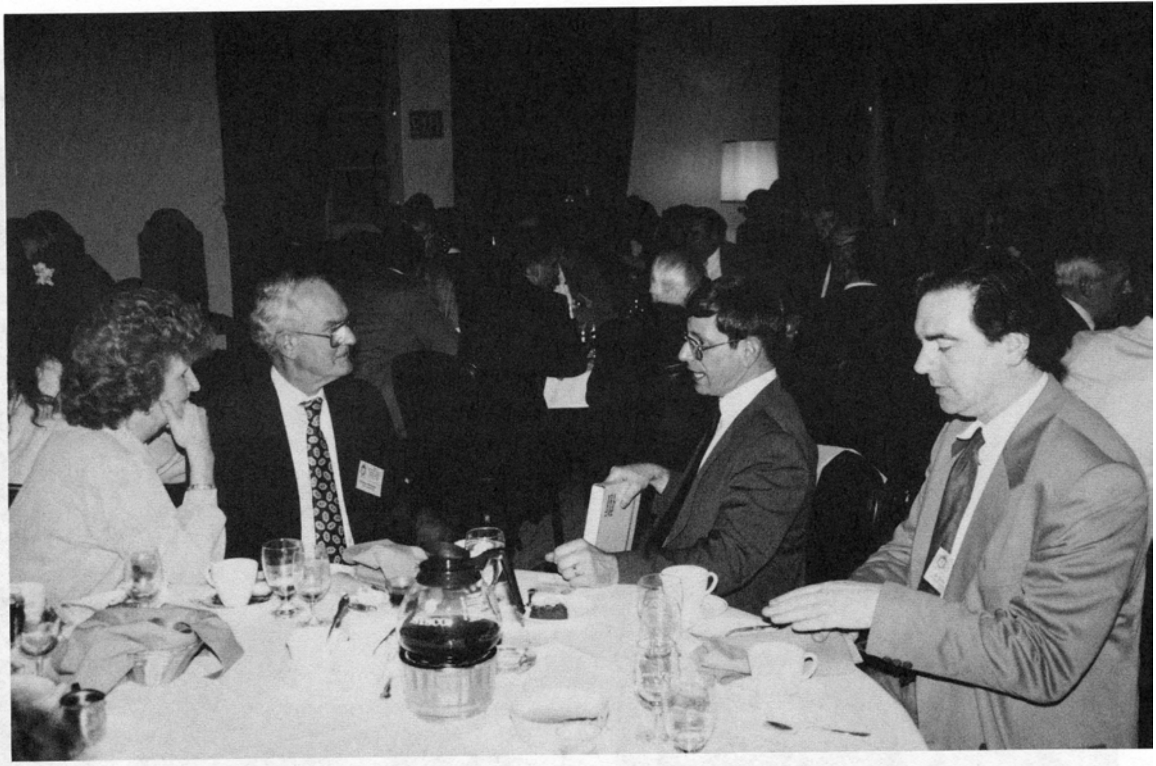
Buddy Coffey has a captive audience



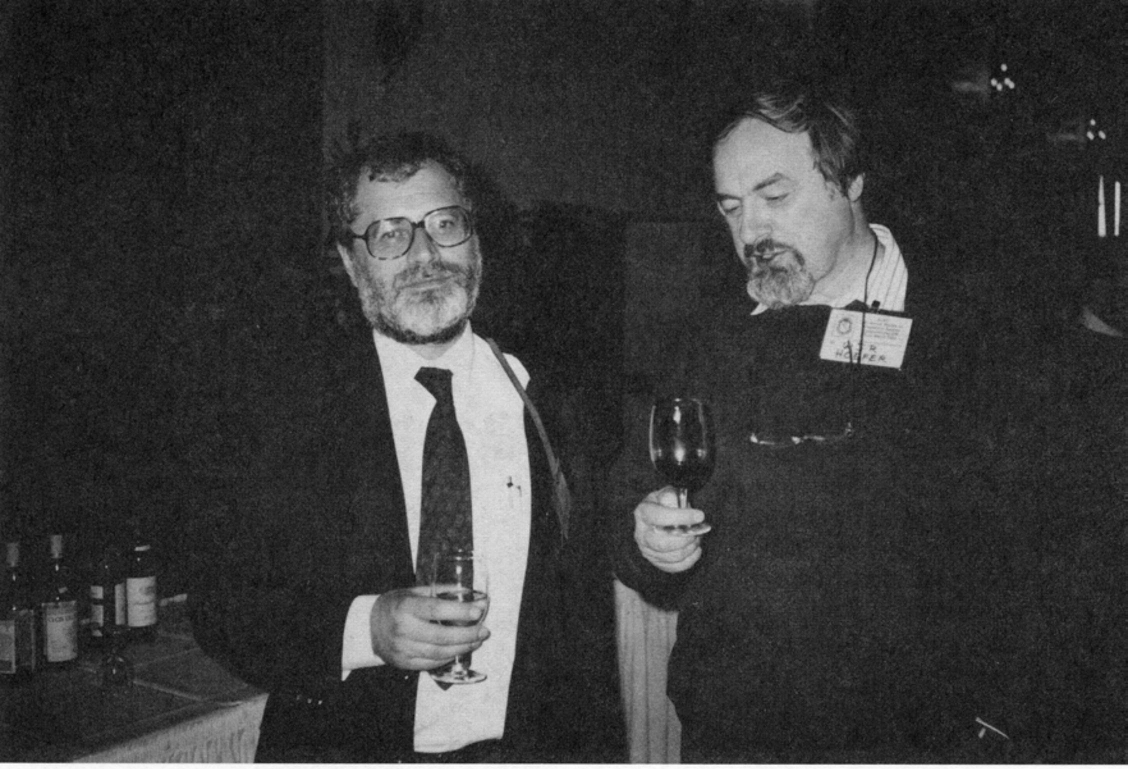
The TLM Gurus: Chris Christopoulos and Wolfgang Hoefer toast their success



"Mr. Nec", Jerry Burke shows Greg Hoech and Ed Miller how it is done



Editor Emeritus, Bob Bevensee with his wife Mae



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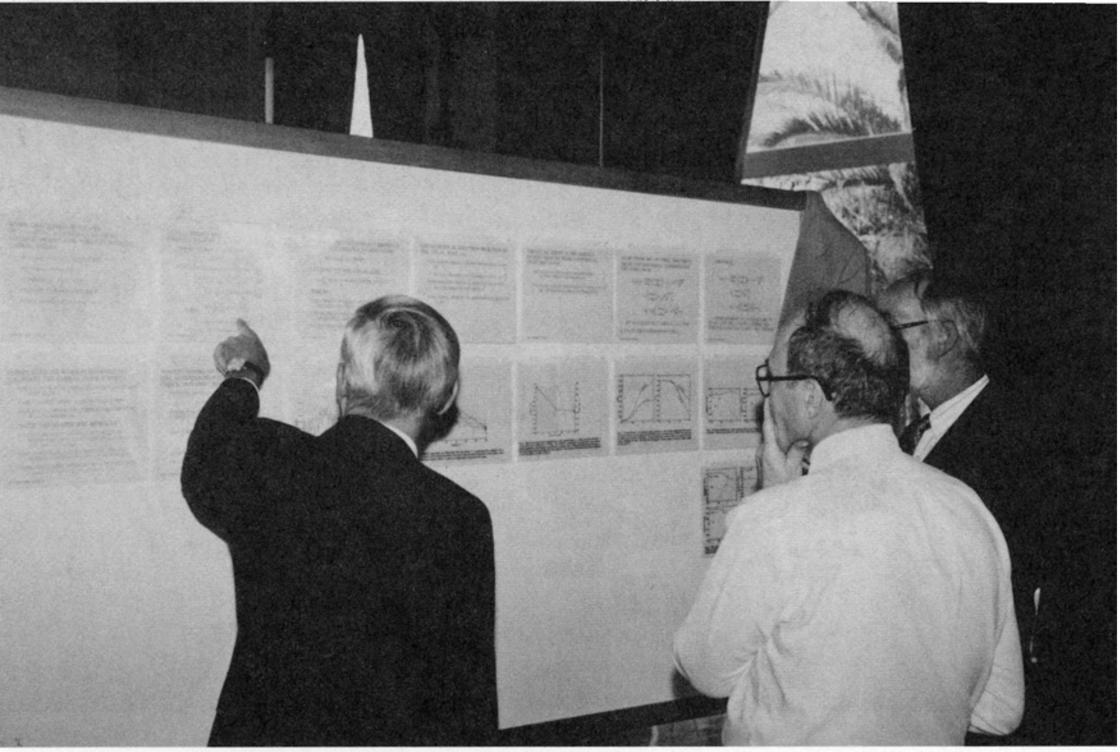
Invited guest Yuaren Qiu enjoys the speaker's comments



"Mr. Neo", Jerry Burke shows Greg Hoeck and Ed Miller how it is done

Conference Chairmen, Pat Foster, ACES '92 and Perry Wheless ACES '93

Editor Emeritus, Bob Bevensee with his wife Mae hear from David Stein, Editor-in-Chief.

For information regarding ACES or to become a member in the Applied Computational Electromagnetics Society, contact ACES Secretary, Dr. Richard W. Adler, Code EC/AB, Naval Postgraduate School, Monterey, CA. 93943, telephone (408) 646-2352, Fax: (408) 649-0300. You can subscribe to the Journal and become a member of ACES by completing and returning the form below.

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