APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

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ACES NEWSLETTER STAFF

Paul Elliot, Editor
ARCO Power Technologies, Inc.
1250 24th St. NW, Suite 850
Washington, DC 20037 U.S.A.
Phone: (202) 223-8808 Work
Phone: (703) 938-3626 Home
Fax: (202) 223-1377
E-mail Paul@apti.com

Reinaldo Perez, Associate Editor
Jet Propulsion Laboratory, Mail Sta. 301-460
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109 U.S.A.
Phone: (818) 354-9771

ACES NEWSLETTER COPY INFORMATION

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Send copy to Paul Elliot at the above address in the following formats:

1. A hardcopy.
2. Camera ready hardcopy of any figures.
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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

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

OFFICER'S REPORTS

PRESIDENT'S REPORT

Elsewhere on these pages you will read about the activities of our various committees, and you should be impressed. ACES is functioning across the entire spectrum of our mandate to serve the computational electromagnetics community. I am especially pleased to note these activities that are jointly performed with other organizations, such as the ACES/TEAM workshops, and those that are international. In the latter category we note the vitality of the UK Chapter of ACES, and the successful ACES/TEAM workshop that Tony Fleming organized in Australia. (Tony, thereby, gets credit for an international project, as well as a joint workshop).

The ACES/TEAM workshop that was held in conjunction with the Conference on Electromagnetic Field Computation (CEFC) this past August was another highly successful project, as reported by Kent Davey in this Newsletter. Several of the papers that were presented at that workshop are being reviewed for publication as a regular contribution to our Journal. ACES can be a vehicle for supporting TEAM, and other formal and informal groups.

As I reported in the last Newsletter, we are developing a relationship with the Japan Society of Applied Electromagnetics in Materials, and its journal, the International Journal of Applied Electromagnetics in Materials, which is published by Elsevier, will be made available to ACES members at the rate of US$ 50.00 per volume.

Russell Taylor, the chairman of the Code Users Group Committee, is developing an electronic bulletin board in conjunction with a government related computational electromagnetics project. This will enhance ACES credibility in the computational electromagnetics community, and can be a significant service to ACES.

We continue to need volunteers to maintain these and other activities. If you are interested in offering your services, please contact the appropriate committee chairman, or me.

Harold A. Sabbagh
Sabbagh Associates, Inc.
P.O. Box 7706
4639 Morningside Drive
Bloomington, IN 47408
(812) 339-8273
(812) 339-8292 (FAX)
E-mail has@sabbagh.com

SECRETARY'S REPORT

Recently, the Board of Directors authorized ACES to obtain a credit card capability, for the convenience of international members when paying membership and other fees. We are struggling to find a bank that will approve us for credit card usage. We do not have a "regular place of business with a storefront and merchandise for sale to the general public"! (SIGH!).

E-mail is changing the way we communicate. Six months ago, we used the fax for 80% of our secretary communications. Now, E-mail is reducing the impact of the fax. The article by Chalmers Butler, in this issue, was sent to us via E-mail using an ASCII file in TEX format! (Maybe we should standardize on TEX-like word processors). Can anyone suggest a convenient medium for figures, drawings, etc. compatible with E-mail transmission?

Richard W. Adler
ACES Secretary
E-mail: 5541304@mcimail.com

COMMITTEE REPORTS

ACES EDITORIAL BOARD

REGIONAL WORKSHOPS

The first ACES-organized regional workshop, arranged by Tony Fleming (Australia), and co-sponsored by TEAM (Testing Electromagnetic Analysis Methods), was successful beyond expectation and beyond its technical content (itself a praiseworthy accomplishment). This August 1992 workshop resulted in new interest in ACES among our colleagues, and this new interest may lead to the formation of an Australian chapter. Furthermore, innovative ways to fund workshops and the associated publicity were implemented.

Equally successful was a TEAM-organized workshop, also in August 1992 (but in the USA) and co-sponsored by ACES. We welcome these opportunities to continue working with TEAM, the true pioneers of benchmark problem solution workshops. Our interactions with TEAM have been advantageous to both groups, especially from the standpoint of promoting a "cross—pollination" of ideas and techniques across applications-area boundaries and thereby eliminating counter-productive "boundary conditions" which have divided the computational electromagnetics community. We shall help publicize new TEAM and ACES benchmark problems and solutions.

Regional workshops benefit ACES and our members in many ways, but they are of special interest to the ACES Editorial Board for two reasons. They are a potential source of publishable material, especially new types of publishable material including benchmark problem solutions. In addition, they can be an incentive for "computational electromagneticists" to become subscribers (members). The resulting expansion of our circulation base in various regions helps us serve the worldwide professional community and makes our publications even more attractive to authors.

(Additional information regarding these two workshops can be found in the two workshop reports published in this issue of the ***ACES Newsletter***. Previous Joint ACES/TEAM Workshops have been in Canada, Japan, and Italy.)

PAPERS AND ARTICLES

The next regular issue of the ***ACES Journal*** scheduled for publication in June 1993, continues (and expands upon) our tradition of diversity. In addition to several antenna papers, the issue (tentatively) will include papers on magnetostatics, power transmission, non-destructive evaluation, input-output issues, computational hardware issues, hybrid techniques of computation, and a new computational diagnostic tool. (The present issue is a special issue on computational bio-electromagnetics. Other special issues are being planned and announced, and as explained in a previous committee report, we are investigating ways to acquire the financial resources necessary to publish more special AND regular issues each year -- while also maintaining membership affordability worldwide)

This diversity among paper topics needs to be maintained for at least two reasons, one of which is to promote the aforementioned "cross-pollination." In addition, shifts in various national economies will result in employment changes for some of our colleagues. ACES needs to remain responsive to members and prospective members who transition from the defense sector to the commercial sector and as a result, to different electromagnetics technologies.

Review papers, topical reprint books, and an electronic publishing feasibility assessment are being considered as "long-term" projects, but we have not yet been able to expend significant effort in these areas.

Meanwhile, two ***ACES Newsletter*** efforts are underway. The first of these efforts is a solicited articles campaign. We have already identified several new contributors for articles, and code developers are finding that an ***ACES Newsletter*** article is an excellent indirect marketing tool. (Articles are required to contain some technical detail as opposed to consisting entirely of code capability descriptions.)

Our other ***ACES Newsletter*** effort is an encouragement and support of "parallel activities" which can generate publishable material of the type envisioned by the Founders of ACES. These activities include software exchange, ACES-sponsored code user groups, and software performance benchmarking activities. Also of interest to us are joint activities with several other professional societies in various regions of the world. These activities can include jointly-maintained data bases (of solved problems, code performance data, and predicted or measured data for code validation), joint workshops which focus on computational issues (possibly involving cross-validation of predicted and measured data), and jointly-sponsored code user groups.

REGIONAL COORDINATORS

Recent developments -- a promotional and invited paper campaign spearheaded by **Duncan Baker** (South Africa), the Australian Regional Workshop, a projected increase in demand for our publications, and an increase in non-USA membership have established a need for a network of regional coordinators. These coordinators can (1) organize regional workshops and chapters, (2) mail letters and announcements within their respective regions (to reduce intercontinental postal expenses), and (3) establish regional bank accounts (to facilitate currency exchange and transfer of funds for payments of annual ACES membership dues and for purchasing ACES publications). I have asked the Editors to help us locate members interested in serving as regional coordinators, and I have recommended that we establish this network jointly with TEAM and other interested groups.

TECHNICAL AND SERVICE AWARDS

Wes Williams (USA) is developing procedures to select recipients of the Outstanding Paper Award, - - possibly separate awards for ***ACES Journal*** papers and for ACES Symposium papers. This award has already been authorized.

I have proposed an Exemplary Service Award to be presented to individuals who contribute substantially to ACES but in non-prominent capacities (i.e., at the committee level). Several of our Editors, as a result of their service to ACES, were my inspiration in proposing this award.

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 was held on July 25, 1992 following the IEEE-APS International Symposium in Chicago. Eleven individuals attended the day-long workshop, and each is in the process of formalizing at least one canonical problem. The proposed problems will be published in an upcoming ACES Newsletter, and a summary will be published in a future issue of the IEEE Antennas and Propagation Society Magazine.

In addition, a TEAM (Testing Electromagnetic Analysis Methods) workshop was held at the Fifth Biennial Conference on Electromagnetic Field Computation (Harvey Mudd College, August 6-7, 1992). Forty four participants attended the workshop, and discussion focused on TEAM problems 9, 10, 13, 15, and 16.

Summaries of both workshops will be available in the near future.

Andrew F. Peterson
Georgia Institute of Technology
School of Electrical Engineering
Atlanta, GA 30332-0250
(404) 853-9831

CODE USER'S GROUP COMMITTEE

Since my last committee report, in which I appealed for greater participation in the Users Group, I have received no responses. I had been at a loss as to how to create greater interest until an on-line Bulletin Board was suggested. So we are in the process of establishing an ACES BBS. The plans are to have it on the INTERNET network (see Randy Jost's article in the July '92 ACES Newsletter). It will be associated with other organizations interested in Computational Electromagnetics. We expect to be able to support distribution of Public Domain Software as well as on-line dialog and general discussions. If you have any inputs please let me know - my mailing address, phone number and E-Mail address are below.

We expect to have the BBS up and running shortly (a few months). I will describe its use in detail in the next newsletter, but if you would like to be notified as soon as it's available, send me a message to tell me your E-Mail address.

The objective of the Users Group is to provide assistance, when needed, to our members. This could possibly be accomplished by providing access to a database which is a compilation of experiences others have had in solving problems (both things that worked and those that didn't). Of course, a widely based compilation requires the input of many experienced people. That's why we need your help! If we can get some help, I hope to get the Modeling Handbook (see my committee report in the July '91 ACES Newsletter) on the BBS.

Dr. Russell W. Taylor
McDonnell Douglas Helicopter Company
5000 East McDowell Road
Mesa, AZ 85205-9797
(602) 891 - 5539
(602) 891 - 6003 (FAX)
taylor%hyades.decnet@orion.mdhc.mdc.com

COMMITTEE ON ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

In the September 1989 ACES Newsletter I raised a question as to the importance and viability of incorporating Artificial Intelligence (AI) technology into the arena of EM analysis and design. A group of ten interested individuals met for about 2 hours at our 6th Annual Review of Progress of ACES in March of 1990. Since that time I have continued to get better acquainted with the AI community progress as it might relate to EM analysis and design. This has been a slow process. I was unable to attend the 7th ACES Review in 1991. At the last minute I was able to make it to the 8th ACES Review for one day so little work has been done, basically because I haven't been able to be a proactive leader.

It is time now to rethink the connection of ACES and AI. The AI community is making great strides in several areas where funds have been available for research and application. In areas like EM, little or no progress is being made as no focused funded program is underway. There are several topics that are worthy of investigation in the AI/EM area. The real question though is whether anyone with money to spend agrees. I need your help in identifying sponsors to help focus studies to determine the feasibility of Expert Systems, etc. for EM analysis and design. This field is complex and single part time investigators make very little progress. Having good ideas is important but a concentrated team is needed to carry anything to a useful conclusion. I have come to believe that without a sponsor with funding, not much will be accomplished. What do you think? Please contact me with your suggestions and comments.

Wayne Harader
Ball Communications System Division
10 Longs Peak Dr.
P.O. Box 1235
Broomfield, CO 80020-8235
(303) 460-2289
(303) 460-2315 FAX

SOFTWARE EXCHANGE COMMITTEE

Frank Walker and Dr. Andrew Terzuoli, co-chairman of the Software Exchange Committee, are currently working to go to press with the 1993 edition of the ACES Software catalog. One unique feature of this effort is that it expands upon past listings of software available to ACES members in an attempt to identify the growing number of commercials and private codes that are available from commercial, government, and educational institutions. So far more than 70 different developers of computational electromagnetic related software have been asked to provide summaries of their software for inclusion into the catalog. In addition, these same developers have been invited to demonstrate their analysis software and related products at the 1993 ACES Conference in a repeat of last year's popular Vendor Special Session held in the Naval Postgraduate School Ballroom. The first draft of the catalog is expected to be prepared in time for distribution at this event on Tuesday afternoon, March 23, so plan to attend.

It is not too late for you to identify a prospective candidate software for inclusion into the catalog. If you have a suggestion or just want to confirm that your favorite analysis software is included in the catalog please contact Frank Walker. Please, no requests for software developer or vendor listings prior to release of the catalog. Correspondence can be forwarded to:

Frank Walker
Boeing Defense and Space Group
P.O. Box 3999; Mail stop 84-05
Seattle, WA 98124-2499
(206) 773-5023
E-mail: Walker@atomic.Boeing.com

The Software Exchange Committee is currently seeking suggestions to improve ACES software exchange and individuals to implement these suggestions.

REGIONAL ACTIVITIES COMMITTEE

Frank Walker, Chairman of the Regional Activities Committee, is currently involved in discussions with Dr. Gary Miller, '94 APS Conference Steering Committee Chairman, concerning ACES participation in that regional activity. APS has planned its annual joint APS/URSI for the third week of June, 1994 in Seattle, WA.

Basically, the option available to ACES is to participate along with APS and URSI as a Conference co-sponsor. In addition to encouraging ACES member participation in regional activities, this opportunity may offer some relief for the increasing number of ACES presenters that have in recent years forced the Monterey ACES Conference to go to a multiple session format.

So far, the APS Regional Activities Committee has not responded favorably to suggestions of a more limited ACES participation such as a "Special Session" or "workshop" format. There does not seem to be sufficient incentive for APS to share its Conference with other than a dedicated participant.

ACES participation in the 1994 APS sponsored Conference in Seattle will require a minimum of 60 papers to fill three days of ACES session presentations. ACES would participate along with APS and URSI as Conference sponsors and ACES would receive separate ACES registration fees as well as share a proportional expense of the Conference costs. Each ACES registrant at the Conference will receive a color coded badge to allow attendance to the ACES session and a copy of the digest of published ACES papers. We can negotiate a separate ACES vendor fair during the week of the Conference and can provide ACES short courses and workshops on Friday of the week of the Conference. APS anticipates net revenue in excess of $250,000.00 from this Conference. We can share in these proceeds if there is sufficient interest among our membership for this regional activity. The key to the financial success of the proposal is in our ability to draw sufficient registration to the ACES portion of the APS Conference to make a profit, without adversely effecting our ACES Conference in Monterey in March.

This proposal is being submitted to the members of the ACES Board of Directors for consideration. If the Board decides to commit to participation in the 1994 event, APS will assign a representative of ACES to the APS Conference Steering Committee.

If you have comments on this topic or wish to participate in the Regional Activities Committee please contact Frank Walker.

Frank Walker
Boeing Defense and Space Group
P.O. Box 3999; Mail stop 84-05
Seattle, WA 98124-2499
(206) 773-5023
E-mail: Walker@atomic.Boeing.com

The Regional Activities Committee is currently seeking suggestions for regional activities worthy of ACES participation and individuals to implement these activities.

SUMMARY OF THE ACES/TEAM INTERNATIONAL WORKSHOP

TELECOM AUSTRALIA RESEARCH LABORATORIES
AUGUST 14, 1992

The Workshop titled "Directions for the Nineties", was attended by approximately 80 people, comprising for the most part fully paid registrants, plus a small number of complimentary attendees. A pleasing aspect of the attendance was that around 15-20 international visitors were present, and this was due to the effectiveness of the "piggy-back" scheduling of the Workshop in between the Asia-Pacific Microwave Conference held in Adelaide 11-13 August, and the 14th Triennial International Radio Science Union Symposium, held in Sydney 17-20 August. The Workshop was conducted on site at Telecom Research Laboratories (TRL), in Clayton, about 25 km south-east of Melbourne central. Conveniently, a new building, complete with auditorium and adjoining display foyer, and special functions facilities, had been completed less than a year earlier.

In addition to TRL, the sponsoring organisations and agencies included the IEEE Victoria Section, the Defence Science and Technology Organisation (DSTO), the Commonwealth Science and Industrial Research Organisation (CSIRO), and the Institute of Radio and Electronics Engineers [Aust].

Technical Programme

Harry Wragge, the Director of Research at TRL, opened the Workshop, while Ed Miller gave a welcoming address on behalf of Hal Sabbagh, the ACES President. Tony Fleming and Greg Haack then alternated the chair for the rest of the programme. Thus, the first ACES/TEAM meeting in Australia was underway.

Ed Miller discussed the likely impact of future computers on computational electromagnetics (CEM), detailing operation counts for both integral and differential equation (IE/DE) methods. Jerry Burke detailed the improvements and developments to be found in the upcoming release of NEC4. Tapan Sarkar spoke about surface and volume integral equation approaches for solving finite conducting/ dielectric structures, such as microstrips. Bach Andersen then gave a rundown concerning the application of the finite-difference-time-domain method to portable antennas. To finish off the invited papers, Ed Miller gave a most interesting talk about visual EM, including a rundown of "stored-solution modes" and "generated-solution modes" that demonstrated the capabilities of the HyperCard system.

A panel session, involving 8 separate and varied topics, concluded the technical portion of the day. This session was an eminent success; apart from anything else, it allowed the Australian EM community an opportunity to learn about the depth of work being pursued within the country. The session was organized quite naturally around the EM spectrum, with the lower frequency topics leading off, and the higher frequency topics following.

Overall technically speaking, the day was an outstanding success, with participants and attendees being exposed to a wealth of EM diversity on many fronts, such as IE/DE methods, military and non-military applications, and TEAM/ACES applications. As stated, from a local viewpoint, it established the viability and utility of such workshops. Hopefully, it will encourage other non-U.S. ACES/TEAM Workshops.

Plans have been made to repeat the workshop, including approaches to potential guest speakers, and these have been well received.

Software Exhibition

An integral part of the day was a trade exhibition held in the adjoining foyer next to the auditorium. Four commercial software distributors were involved, and all were pleased with the level of product inquiries. From a financial viewpoint, each exhibitor was also a sponsor, there being two tiers of sponsorship that involved a charge for a general mailout including vendor information sheets, and a separate charge for logo space on the main registration announcement.

Post Conference Dinner

Following the conclusion of the workshop, a most enjoyable dinner was conducted at cost and on site that was attended by 40 people, including nearly all of the international visitors.

Budget Considerations

There were three groups of financial sponsors, TRL being the main sponsor, the commercial software vendors, and also an additional small sponsorship involving airfare. One large cost was the food catering which fortunately was able to be done on site. An important consideration was to have a Proceedings that was compatible with other ACES documents, regardless of cost. The registration charge included morning and afternoon teas/coffees, a smorgasbord luncheon with entree, post workshop refreshments, and Proceedings.

Summary and Outcome

The first ACES/TEAM meeting within Australia was an outstanding success, financially, technically and socially. A number of attendees have been very favourable in their comments. As noted earlier, one important element of this success was the level of sponsorship achieved. It may be possible to conduct workshops without this level of sponsorship, but then registration costs would need to be higher which would cut into the number of registrants.

The organizing committee was not just at an "advisory" titular level, but were able to act autonomously. To this end, all were colleagues who had an established working relationship.

The local computational EM community achieved a successful coming together for the first time, and the event demonstrated the usefulness of ACES/TEAM as a forum. It is expected that an Australian ACES chapter will now be formally created, complete with office bearers, providing local events, such as short courses and possibly a newsletter. The workshop is likely to become a regular event, perhaps occurring biennially. The present success demonstrated the usefulness of piggy-backing the Workshop with other conferences or short courses.

A.H.J. Fleming, Workshop Organizer
Telecom Australia Research Laboratories
Clayton, Victoria, Australia

SUMMARY OF THE JOINT TEAM/ACES WORKSHOP

HARVEY MUDD COLLEGE
CLAREMONT, CA, USA
AUGUST 6-7, 1992

The opening remarks for the workshop were given by Dr. Harold Sabbagh. This workshop followed the 5th annual CEFC (Computational Electromagnetic Fields Conference). There were forty four participants in attendance at the workshop. A list of participants is included. A number of technical discussions were generated on problems 9, 10, 13, 15, and 16. Presenters for these problems were as follows:

Problem 9, Kent Davey and Marco Raugi
Problem 10, Oskar Biro
Problem 13, Oskar Biro, Koji Fujiwara, Lauri Kettunen
Problem 15, Harold Sabbagh
Problem 16, A. Bossavit and N. Richard

Problem 9 -- 50 Hz coil traveling down a conducting tube

Kent Davey approached the problem using a boundary element program. The boundary element code solves an eddy current problem by placing equivalent surface currents on either side of a conducting interface. The currents are chosen to satisfy boundary conditions on tangential E and H. The first part of the code is based on a commercial package (from Integrated Engr. Software in Winnipeg, Canada). To account for velocity effects, the code is "tricked" into thinking the problem is moving by enhancing the conductivity based on A and $\partial A/\partial Z$ for the zero velocity condition. The results agree reasonably well with the analytic condition. This infers that the end user of commercial packages could account for velocity effects without this capability being imposed in the code. The code required 179 elements, and ran 30 minutes on a 486 33MHz machine.

Marco Raugi analyzed the same problem using coils. The coils are treated as individual circuits with analytic expressions used for the mutual coupling between any two coils. The problems were run on an IBM RISK machine with 500 coils max.

Reasonably good agreement was realized between the two methods. When the axial field was considerably lower in magnitude than the radial field, the boundary element method was shown to deviate from the analytic solution in its calculation of the smaller axial component. Perhaps more elements are need to correct this problem.

The mutual coil solution was off a bit more in error. Increasing the model length from 150 mm to 400 mm showed no improvement in the solution. This is perhaps due to the fact that the number of coils was limited to 500. A larger density of coils is required near the source.

Problem 10

Oskar Biro presented 3 solutions to problem 10, steel plates around a coil.

A, V-A with A_n continuous
A, V-A, A_n discontinuous at iron-air interface
A reduced vector potential

(A, V-A means vector potential side 1, vector and scalar potential on side 2) Methods 2 and 3 gave nearly equivalent results which were more accurate than method 1. Method 2 requires more unknowns than method 1 on the surface since $\partial A/\partial N$ is discontinuous. This additional accuracy on the surface yielded a superior solution. The reduced vector formulation was slower, but yielded nearly the same solution.

Problem 13

Oskar Biro applied a 1) reduced and total scalar formulation, 2) T edge - ϕ $H = T - \nabla\phi$ with T modeled with edge elements, 3) R (edge) curl $1/\mu$ curl A = curl T.

Fujiwara modeled the problem as a 3 component vector potential solution.

Lauri Kettunen approached the problem using an integral formulation

$$H = H_i + H_m$$

$$H_m = -\nabla \frac{1}{4\pi} \int \frac{\overline{M}\cdot(\overline{r}-\overline{r}')}{4\pi R} dv' - \nabla\psi$$

with tetrahedral elements modeling M. All solutions showed close agreement in theory except at the steel corners of the box, where all seemed to drop by as much as 25% below measured data. The one exception was the total scalar potential formulation. One explanation might be the modeling of the current source. Higher number of elements seemed to raise the predicted solution towards the measured data. Koji supplied new measurements for the problem as well as a new BH curve.

Problem 15

Harold Sabbagh solved the problem of an air core probe over a thick aluminum plate using a vector integral solution. The solution involved use of the Greens dyadic integrated over the volume of the test region. If the Green dyadic is known for the geometry used, only the crack in the problem need be factored into the final analysis, i.e., only regions which constitute a perturbation from the homogeneous assumptions in the Greens function. Very accurate results were realized with 1000 unknowns in 2 hours.

Problem 16

A. Bossavit presented some work with N. Richard for problem 16 - magnetic damping and torsional modes in a beam (like problem 12). Bossavit analyzed the first 6 mechanical frequency modes. Modes 2, 4, and 6 were torsional modes. Bossavit maintained that the torsional modes suffered from significant dampening. Accounting for damping with mode 2, the most significant of the first 3 torsional modes, resulted in closer agreement to experiment.

TECHNICAL DISCUSSION

Harold Sabbagh was asked to outline the details of his integral formulation. After doing this it was stated that the method would be efficient if one knew the Greens function for the global unperturbed body in question, but that this is, in general, quite difficult. Some options for cracks in a box were suggested based on the solution of sources over the entire box.

Prof. Takayoshi Nakata asked why the solutions in problem 13 all showed a loss in accuracy near the lower lateral edge of the corner. Giorgio Molinari suggested the measurements were taken 2 - 3 mm below the lower lateral corner edge. In addition, at the corner, both FE and integral methods should expect trouble. Participants said they would study at the fields just below this edge as well as raise the number of elements.

NEW PROBLEMS

Harold Sabbagh, with A. Bossavit, submitted two high frequency wave guide problems, the first a 2D problem, and the second a 3D waveguide with variable conductivity on the walls, each with an aperture in the guide.

Kent Davey proposed a problem based on a superconducting coil over a ferromagnetic rail. The problem is aggravated by the slight offset of the rail making accurate force calculations difficult. The problems has 2D static, 2D eddy current, 2D nonlinear, 3D static, 3D eddy current, and 3D nonlinear components to each of the 6 stages. A write up of the problem must be completed.

Noreo Takahashi presented a 3D static force problem of a coil surrounding a magnetic yoke with a movable control plunger. Force measurements exist for the plunger. This problem will be adopted as problem #20. Problem 18 & 19 will be the waveguide problems by Harold Sabbagh and A. Bossavit.

Closing Remarks

Closing remarks were made by Harold Sabbagh. ACES will continue to publish our workshop summaries as newsletter articles. Details of the solutions will be reviewed and published in the ***ACES Journal***. Subscriptions for either the newsletter or journal are available through

R. W. Adler
Naval Postgraduate School
Code EC/AB
Monterey, CA 93943
(408) 646-2352

Kent Davey

THE HISTORY AND SCOPE OF THE COMPUMAG SERIES OF CONFERENCES

Professor Osama A. Mohammed
Chairman, COMPUMAG International Steering Committee

The broad aim of the series of the COMPUMAG - Conferences on the Computation of Electromagnetic Fields - is to review, discuss and disseminate the most recent developments in numerical computation of electromagnetic fields for the international community of physicists, engineers and researchers engaged in the design of electromagnetic devices in industry, academia, national and international research laboratories.

The COMPUMAG series of Conferences on the Computation of Electromagnetic Fields was inaugurated in 1976, and since then has been held regularly every two years, in different venues in Europe, America and Asia, using English as the official language. The International Steering Committee held its first meeting in September 1974 at Rutherford Appleton Laboratory, and since then has always met regularly to support the activity of Conference organizers.

Previous COMPUMAG Conferences were held at Oxford, U.K. (1976), Grenoble France (1978), Chicago, USA (1981), Genoa, Italy (1983), Fort Collins, USA (1985), Graz, Austria (1987), Tokyo, Japan (1989), and Sorrento, Italy (1991). The ninth COMPUMAG conference will be held in Miami, Florida, USA, October 31- November 4, 1993.

Topics of interest to the COMPUMAG Conference include:

- Magnetostatic and electrostatic field calculations for both linear and non-linear problems.
- Time-dependent fields, including the transient and steady state behavior of electromagnetic devices, eddy currents and skin effect.
- Modelling of material properties (including the numerical treatment of anisotropy, hysteresis, permanent magnets and diamagnetism) and solution of special prob lems (e.g. moving boundary and inverse problems).
- Electromagnetic fields coupled to mechanical, electronic, thermal and/or flow systems. Examples include medical systems, actuators, variable speed drives, superconducting magnets, electro-heat, nondestructive testing, recording heads, nuclear fusion and power electronic devices.
- Original applications of computer programs for the design of electromagnetic devices, with particular reference to the calculation of local and integral parameters.
- Numerical methods and techniques, including finite elements, boundary elements, finite differences, moment methods, eigenvalue and high frequency problems, equivalent circuit techniques, mesh generation, error estimation, inverse problems, optimization, parallel com- puting, methods of solving large sets of equations with dense or sparse matrices of coefficients.
- Software methodology and interactive computer aided design for electromagnetics. Topics of interest include visualization, knowledge based systems and AI-techniques.

The aims of the COMPUMAG International Steering Committee (ISC) are to ensure the high scientific standard and quality of accepted papers, to establish rules concerning conference organization, to provide continuity of the series of Conferences as well as define policies with respect to other conferences interacting with COMPUMAG. The ISC activities also include the selection of the Editorial Board and the provision of backing and supervision in the reviewing process, the selection of venues and Chairmen of forthcoming Conferences, the scheduling of Conference deadlines, the discussion and analysis of the Conference budget, the choice of invited speakers, panelists and the approval of the Conference program and the negotiation and approval of agreements and coordination of activities with other scientific bodies.

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 industry. This issue features the following "Perspectives" article by Dr. Arje Nachman. This issue also includes two articles which follow up on previous perspectives articles: "Paradox in Computing Electric Field from Currents, Part II" by Professor Chalmers Butler, and "Modeling Polarimetric Signatures of Precipitation" by Dr. Aydin & Dr. Zrnic.

PERSPECTIVE

Arje Nachman, Program Manager
Physical Mathematics and Applied Analysis
Directorate of Mathematical and Information Science
Air Force Office of Scientific Research
Bolling AFB, Washington, DC 20332

At the Air Force Office of Scientific Research (AFOSR) we have identified several areas within computational electromagnetics (CEM) that we believe are important to both the technical community and the Air Force.

One such area is scattering from large objects (compared to incident wavelength). It would be highly desirable to be able to design, at the outset, an airplane in consonance with both RCS and aerodynamical objectives (TQM!). In all fairness, it must be admitted that neither CEM nor CFD have design-speed turnaround (several hours). At least for the CEM part there is some optimism here that a Fast Multipole Method could be such a code. As with all integral equation based methods, FMM avoids spurious dispersion (caused by gridding the exterior domain) and backscattering from numerical boundaries "at infinity". No version of FMM can handle penetrable objects or objects with penetrable coatings. Scattering by topography is also of great importance to the Air Force. Trustworthy appraisal of radar coverage (theirs and ours) is extremely valuable, the more so if it includes refraction/ducting by atmospheric conditions.

The Air Force recognizes its responsibility to the health and safety of all personnel, including those exposed to microwave radiation. The human body is not only a penetrable object but also dispersive, random and quite likely nonlinear. An example of a challenge to the electromagnetics community would be to describe the field inside a 10 cm sphere of Lorenz material illuminated by a single sinusoid of 1 nanosecond duration. As daunting as this problem is, it is just the beginning. Water, the main component of tissue, is not adequately described by Lorenz, Debye or any other classical dispersive ansatz. Indeed, the experimentally obtained graphs of the permitivity and conductivity of water as functions of frequency cannot be reconciled with the classical Kramers-Kronig relationship. It has been suggested by Dr. Richard Albanese (Armstrong Lab, Brooks AFB) that improved convolution integral equations defining the relationship between $\overline{D}$ and $\overline{E}$ and $\overline{J}$ and $\overline{E}$ could rectify matters. Thus far, this has produced a novel Kramers-Kronig relationship which accounts for all of the features of water save the sharp downward spike of the absorption coefficient at 15 Gigahertz (which is what enables us to see!).

Finally, we encourage substantial augmentation of time domain intuition and analysis. The FMM code previously mentioned is a frequency domain code. To do the 10 cm dispersive sphere, or the coated B-2, or chaff, illuminated by a pulse, the CEM community needs to pursue substantial upgrades in modeling and numerical implementation. For example, asymptotic descriptions of dispersive pulse propagation phenomena is critically dependent upon the dominant contribution to the propagated field behavior at a given space-time point. For a given dispersive medium, the dominant contribution to the field behavior is completely determined by the dynamics of the saddle points of the complex phase function of the dispersive medium, the initial pulse envelope spectrum, and the input pulse carrier frequency. For initial rise and/or fall times of the input pulse envelope that are typically less than the medium relaxation time, the saddle point dynamics then depend only upon the dispersive properties of the medium (1-3). However, as the initial rise and/or fall time of the input pulse increases above the medium relaxation time, it is found (4) that the complex phase function must be modified so as to include the rise/fall time parameter. The saddle point dynamics then depend not only upon the medium dispersion but also upon the input pulse properties. Equally compelling time domain work by H. Moses (5) illustrates the benefits that might accrue to researchers and their customers from progress in this area.

1. K.E. Oughstun and G.C. Sherman, "Propagation of Electromagnetic Pulses in a Linear Dispersive Medium with Absorption" (the Lorentz Medium), J. Opt. Soc. Am. B, **5**, 817-849 (1988).
2. K.E. Oughstun and G.C. Sherman, "Uniform Asymptotic Description of Electromagnetic Pulse Propagation in a Linear Dispersive Medium with Absorption" (the Lorentz Medium), J. Opt. Soc. Am. A, **6**, 1394-1420 (1989).
3. S. Shen and K.E. Oughstun, "Dispersive Pulse Propagation in a Double Resonance Lorentz Medium", J. Opt. Soc. Am. B, **6**, 948-963 (1989).
4. K.E. Oughstun and J.E.K. Laurens, "Asymptotic Description of Ultra Short Electromagnetic Pulse Propagation in a Linear, Causally Dispersive Medium", Radio Science, **26**, 245-248 (1991).
5. H. Moses, "The General Solution of the Three Dimensional Acoustic Equation and of Maxwell's Equations in the Infinite Domain in Terms of the Asymptotic Solution in the Wave Zone", J. Math, Physics, Vol 23 (1), 86-101, Jan 92.

A PARADOX IN COMPUTING ELECTRIC FIELD RESOLVED

Chalmers M. Butler
Clemson University
Clemson, SC 29634-0915

The purpose this paper is to provide an explanation of a paradox presented in an earlier paper [1]. The paradox is about two "well known" methods for determining electric field due to a specified current density, which, as is observed in [1], yield different results. In this sequel to [1], we demonstrate that one result is correct and explain why the other is incorrect. It is hoped that the comments below will prove of interest to those who employ vector and scalar potentials in computations of electromagnetic fields.

In [1] we consider the simple example 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 $2h$. The cylinder axis coincides with the z axis of a cylindrical coordinate system and the center of the cylinder is taken to be at the coordinate origin, which means that the upper and lower ends of the cylinder are at $z = h$ and $z = -h$, respectively. The current distribution is of harmonic time variation $e^{j\omega t}$, is circumferentially invariant, and is in a homogeneous space of infinite extent characterized by (μ, ϵ). In [1], E_z on the cylinder axis is determined by two methods, one based on both the vector and scalar potentials and the other on only the vector potential. The corresponding results are derived in [1] and are repeated in the *Appendix* as Eqs. (14) and (15). (For the reader's convenience, equations from [1] that are cited in this paper are listed in the *Appendix*. Equation numbers correspond to those of [1].)

The expression in (1) for $\mathbf{E}$ is the fundamental form for determining the electric field from the vector and scalar potentials while that in (2) is a consequence of eliminating Φ from (1) by means of invoking the Lorentz condition,

$$\nabla \cdot \mathbf{A} + j\omega\mu\epsilon\Phi = 0\,, \tag{16}$$

explicitly. The potentials satisfy the well known wave equations,

$$(\nabla^2 + k^2)\mathbf{A} = -\mu\mathbf{J} \tag{17}$$

and

$$(\nabla^2 + k^2)\Phi = -\frac{1}{\epsilon}q\,, \tag{18}$$

whose solutions in homogeneous space of infinite extent are

$$\mathbf{A}(\mathbf{r}) = \mu \iiint\limits_V \mathbf{J}(\mathbf{r}')G(\mathbf{r},\mathbf{r}')dV' \tag{19}$$

and

$$\Phi(\mathbf{r}) = \frac{1}{\epsilon} \iiint_V q(\mathbf{r}')G(\mathbf{r},\mathbf{r}')dV' \tag{20}$$

in which G is the free space Green's function,

$$G(\mathbf{r},\mathbf{r}') = \frac{e^{-jk|\mathbf{r}-\mathbf{r}'|}}{4\pi|\mathbf{r}-\mathbf{r}'|} . \tag{21}$$

One should note that (17) is a special case obtained by imposing the Lorentz condition (16) on a more general equation derived from Maxwell's curl equations and that (18) is a consequence of subjecting (1) to the remaining Maxwell equation,

$$\nabla \cdot \mathbf{E} = \frac{1}{\epsilon} q , \tag{22}$$

and, subsequently, to the Lorentz condition (16). In general (17) embodies Maxwell's curl equations and the Lorentz condition (16), while (18) embodies (22) and the Lorentz condition. Upon employing (16) to eliminate Φ from (1) to obtain (2), one has an expression for $\mathbf{E}$ which depends only on $\mathbf{A}$. At first thought this may seem strange since the dependence of $\mathbf{E}$ upon charge density q would appear to come only through Φ as in (1). On further reflection, one realizes that q can be expressed in terms of the current density $\mathbf{J}$ through the continuity equation,

$$\nabla \cdot \mathbf{J} + j\omega q = 0 , \tag{23}$$

which perhaps could justify in part the absence of dependence of $\mathbf{E}$ in (2) on Φ. That is, q determines Φ through (18) so, if dependence of $\mathbf{E}$ upon q can be incorporated through the latter's link to $\mathbf{J}$ through (23), perhaps Φ is not needed. But this does not completely justify (2) because one can determine $\mathbf{E}$ from (2) and (19), neither of which ostensibly involves the continuity equation as a link to q. The complete explanation lies in the fact that enforcement of the Lorentz condition (16) is tantamount to enforcement of the continuity equation (23). In fact by taking the Laplacian of both sides of (16), utilizing (17) and (18), and finally invoking the Lorentz condition, one arrives at the continuity equation (23). Hence, when the Lorentz condition is used to convert (1) to (2), one is implicitly enforcing the continuity equation (23). ($\mathbf{J}$ and q in (17) through (23) represent volume densities but are used elsewhere to denote surface densities. Proper interpretation should be clear from context.)

Armed with the above information about representation of the electric field in terms of potentials, we return to our paradox and attempt to explain why (14) and (15) are different. First, we find that $A_z(z)$ and Φ of (15) and (9) do not satisfy the Lorentz condition (16), which in the example under consideration [1] reduces to

$$\frac{d}{dz} A_z(z) + j\omega\mu\epsilon\Phi(z) = 0 . \tag{24}$$

That (24) is violated is readily evident when one observes from (5) and (13) that

$$\frac{d}{dz}A_z(z) = \frac{d}{dz}\left\{\mu\int_{-h}^{h} I(z')K_0(z-z')dz'\right\}$$
$$= -\mu\Big[I(z')K_0(z-z')\Big]_{z'=-h}^{h} + \mu\int_{-h}^{h}\frac{d}{dz'}I(z')K_0(z-z')dz' \qquad (25)$$

and compares this expression with $j\omega\mu\epsilon\Phi$, where Φ is the scalar potential of (9). Clearly, (24) is violated due to the presence of the first term on the right of (25) except in the special case that $I(\pm h) = 0$.

With the Lorentz condition violated, one would not expect the electric field expressions (14) and (15), derived for our simple model from (1) and (2), respectively, to be equal or equivalent. But which is correct and what is wrong? E_z of (15) is correct while that of (14) is wrong because the total charge density on the surface is not complete unless $I(\pm h) = 0$ in which case (14) and (15) agree and both are correct. The surface charge density implied in the computation of Φ of (9) and the surface current density do not constitute a *complete* electric system.

The *total* surface charge density associated with the surface current density $J(z)\hat{\mathbf{z}}$ on the cylindrical surface of our illustration is

$$q(z) = \frac{j}{\omega}\left\{\frac{d}{dz}J(z) - J(h)\delta(z-h) + J(-h)\delta(z+h)\right\}. \qquad (26)$$

The last two terms in (26) are needed to *complete the electric current-charge system.* $\frac{j}{\omega}J(-h)\delta(z+h)$ and $-\frac{j}{\omega}J(h)\delta(z-h)$ are the surface densities of discrete rings of charge at the lower ($z = -h$) and upper ($z = h$) ends, respectively, of the imaginary cylinder on which the current of surface density $J(z)\hat{\mathbf{z}}$ resides. These terms must be present, for, otherwise, the current at the two ends would violate our notion that charge can neither be created nor destroyed. For example, at the upper end ($z = h$) the non-zero current density must "deposit" a charge in keeping with the requirement that an increase in stored charge must attend a net current into a region. Similarly, at the lower end, the net current out of a region must be accompanied by a decrease in charge stored. One may view the lower ring charge as a source and the upper as a sink. With q of (7) replaced by the right side of (26) one finds that the electric field computed from A_z and Φ according to (3) is the same as E_z of (15).

One can arrive at the same results from an alternate point of view. The surface current density can be restated in the form

$$\mathcal{J}(z) = J(z)\big[U(z+h) - U(z-h)\big], \qquad (27)$$

where $U(z)$ is the unit step function. The factor $[U(z+h)-U(z-h)]$ causes the current to be zero outside of $z \in [-h, h]$ and equal to $J(z)$ in this interval. Then, if the delta distribution is accepted as the derivative of the unit step, the surface charge density q determined from the continuity equation is the same as that of (26). When the computation of charge density from current density by means of the continuity equation is interpreted in the sense suggested here in which the surface divergence of a current discontinuity introduces a delta distribution of charge, *i.e.*, a discrete line of charge at a surface boundary at which the component of surface current normal to the boundary or edge is not zero, one finds that the use of Φ of (20) and the charge density determined from (23) (interpreted as surface densities and operators) leads to correct results.

A final observation is of interest. Integration over all space of the charge density of (26) yields zero net charge, whereas the integral of the first term differs from zero by the sum of the integrals of the second and third terms. Thus, the charge density of (26) obeys the principle of charge neutrality over all space but would not sans the second and third terms needed to complete the electric system. The charge density of (9) leading to the incorrect result (14) does not obey this principle.

Representation of $\mathbf{E}$ in terms of the potentials as in (1) or (2) is fundamental to the development of electric field integral equations (EFIE). In order to develop such equations correctly and with confidence, one must have a precise understanding of the role played by the current and charge in the expressions and must be aware of the pitfalls discussed above. This is particularly important if the representation of the surface current employed, as in a series involving unknown constants and basis functions, admits current discontinuities. Such a current representation leads to other problems encountered when one attempts to devise a numerical method for solving the EFIE. These difficulties are associated with behavior of the field at current discontinuities and arise from terms similar the first term of (15). When evaluated on the surface bearing the current such terms become highly singular.

Appendix

In this appendix are collected the equations from [1] which are cited in the paper. The equation numbers correspond to those in [1].

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

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

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

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

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

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

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

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

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

Reference

[1] C. M. Butler, "A paradox in computing electric field from currents," **ACES Newsletter**, vol. 7, no. 2, pp. 18-21, July 1992.

MODELING POLARIMETRIC SIGNATURES OF PRECIPITATION

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

Modeling

In the previous article (*ACES Newsletter*, Vol. 7, No. 2, July 1992) we described polarimetric signatures of precipitation. A scattering model in the general framework (Fig. 1) of observations and simulation of polarimetric variables is pertinent to the readers of this newsletter and is discussed here. The role of various blocks in Fig. 1 and their interaction is as follows. The physical model captures the essence of particular hydrometeor populations; for example it contains the distribution N(**X**) of sizes, shapes, orientations, dielectric constants etc, all of which are lumped in a vector **X**. The scattering model provides the forward scatter and back scatter amplitudes for each distinct hydrometeor type. From the physical and scattering model a fundamental measurand or a derived quantity is computed; for example Z_h indicates a refectivity factor at horizontal polarization, Z_{DR} is the differential reflectivity, etc. These derived quantities are compared to observations in order to relate them to appropriate physical models.

Scattering model

The scattering model should provide the essential ingredients so that the bulk propagation and backscatter properties can be captured. Complex dielectric constant of liquid and frozen water depends on temperature and can be easily modeled. Partially melted hydrometeors require adjustments to the dielectric constant. Good results are obtained by assuming that, for example hail consists of a liquid matrix with ice inclusions; then application of the Maxwell-Garnett formula (Longtin et al., 1990) produces the effective dielectric constant. Because of the large range of radar wavelengths (1.25 mm to 11 cm) and great variety of hydrometeors (raindrops, hailstones, snowflakes and ice crystals) the computational task can be very intense. For hydrometeor sizes small compared to the wavelength (Rayleigh scattering) closed form solutions are available for ellipsoidal shapes.

Scattering from hydrometeors in the resonance regime (as well as Rayleigh regime) can be evaluated by numerical techniques. Waterman's (Waterman, 1969) extended boundary condition method (better known as the T-matrix method) has been successfully used to solve such problems. This is an integral equation formulation which is reduced to a finite system of linear equations; in contrast to the separation of variables approach (e.g., Mie formulation for spheres), the surface of the hydrometeor need not conform with the surfaces of an orthogonal coordinate system in which the vector Helmholtz equation is separable. Nevertheless, the particle surface must be smooth (i.e., no edges), the maximum dimension should be less than 3λ and the ratio of the maximum to minimum dimensions should be less than about 4, otherwise the system of equations may become ill conditioned. Furthermore, even though the formulation is general, so far only rotationally symmetric scatterers (e.g., prolate and oblate spheroids) have been treated due to computational restrictions. Finally, the T-matrix formulation is also suitable for handling layered particles such as melting hailstones modelled as water coated ice.

The microwave scattering properties of raindrops have been quite accurately evaluated using oblate spheroidal models. Hailstones, on the other hand, are more variable in shape and have been modelled as spheres, oblate and prolate spheroids, and cones capped on both ends with spheres or spheroids. Sinusoidal perturbations around spheroidal surfaces have also been used to simulate the protuberances on some large hailstones. All of these shapes can be handled with existing formulations such as the T-matrix method. But, snowflakes and ice crystals cannot be modelled by such smooth shapes, except possibly at the lower microwave frequencies (2-10 GHz)where the wavelength is much

[1] Dept. of Electrical and Computer Engineering, The Pennsylvania State University, University Park, PA 16802

[2]National Severe Storms Laboratory, 1313 Halley Cr., Norman, OK 73069

larger than the ice particles and the bulk shape rather than the detailed shape is of significance, e.g., a hexagonal column can be modelled as a prolate spheroid at λ = 10 cm. Pristine ice crystals are generally in the form of hexagonal columns, needles, hexagonal plates, stellar plates, etc. (Pruppacker and Klett, 1978). These shapes have edges, their width to height ratio can be as large as 20:1, and they can contain large cavities (air pockets). Rimming can cause significant protrusions on these ice crystals as well. Such detailed shape characteristics become very significant for polarimetric scattering at millimeter wave frequencies (e.g., 94 and 220 GHz) where the ice particles may be comparable to the wavelength. Scattering from particles with complex shapes can be evaluated by a frequency domain technique known as the coupled-dipole approximation or discrete-dipole approximation (Purcell and Pennypacker, 1973). In this method the particle is modelled by an array of coupled-dipolar elements on a cubic lattice. As in many other numerical methods, it is not possible to estimate the error in the computed results. Nevertheless, it is generally assumed that increasing the number and decreasing the size of the dipolar elements will reduce the errors. Another promising technique is the finite difference time domain (FDTD) method (Umashankar and Taflove, 1982) in which the object is embedded in a lattice generally composed of cubic cells. Maxwell's equations are then solved iteratively. The E and H fields are computed by finite differences over the lattice as time is increased in uniform increments. Frequency domain results (e.g., at specific radar wavelengths) are obtained by Fourier transformations. For dispersive media this method could produce acceptable results over a narrow frequency band. For wide band results a frequency dependent FDTD formulation may be necessary (Luebbers et al., 1991).

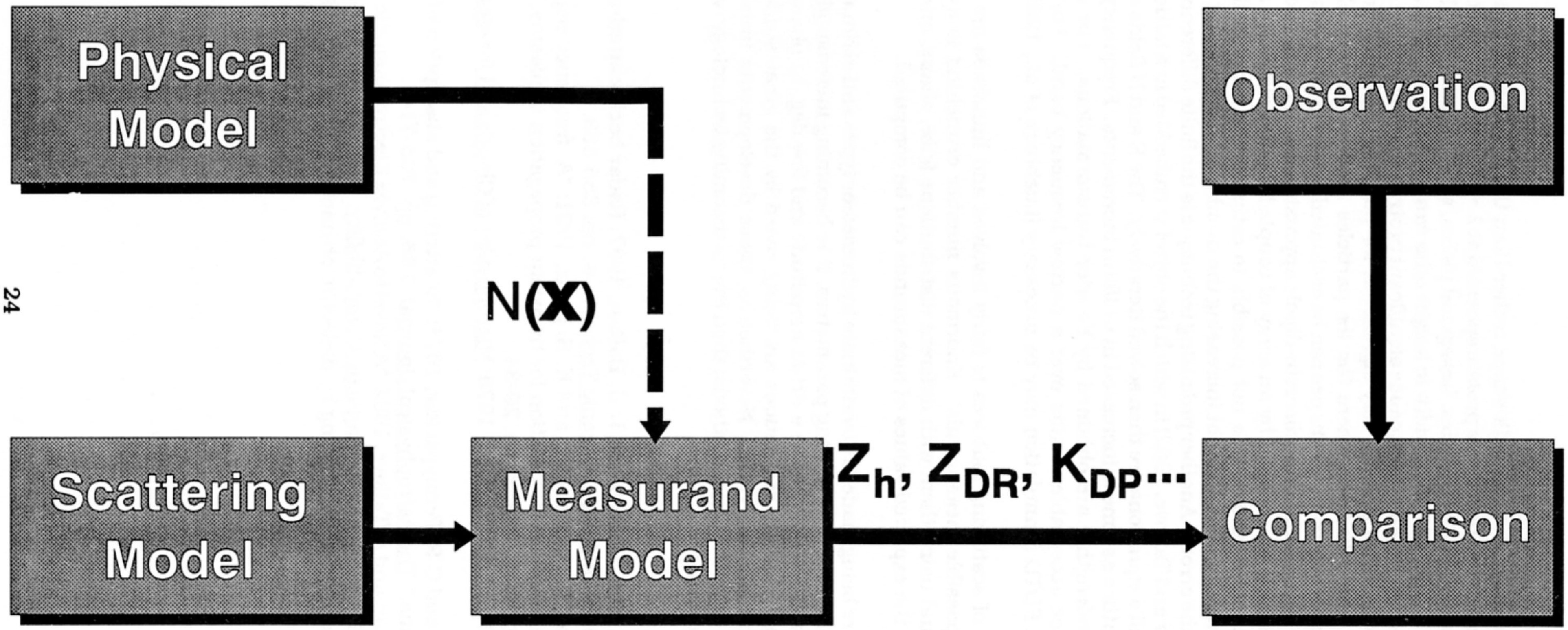
Computation of scattering matrices is fairly involved and hundreds are normally required to produce one set of possible measurands! Enormous number crunching is avoided by storing the scattering matrices and using them with different distributions (size, shape, orientation and material composition) so that the expected values of measurands can be computed.

As attempts are being made to discriminate hydrometeor types and estimate their concentration and sizes from all polarimetric scattering parameters, it is becoming increasingly important to obtain accurate computational results (within a dB in amplitude and few deg. in phase) in reasonable time. Computation time and memory restrictions are being eased by the great strides made in computer technology during the last few years. Nevertheless, these developments must be accompanied by improvements in the computational methods; then the forthcoming technology would be utilized to its fullest potential capability.

References

1. D.R. Longtin, C.F. Bohren and L. J. Battan, 1987: Radar backscattering by large, spongy ice oblate spheroids. J. Atmos. Oceanic Technol., **4**, pp. 355-358.
2. R.J. Luebbers, F. Hunsberger, and K. S. Kunz, 1991: "A frequency dependent finite-difference time-domain formulation for transient propagation in plasma," IEEE Trans. Antennas. Propagat., **AP-39**, pp. 29-34.
3. H.R. Pruppacker, and J.D. Klett, 1978: Microphysics of Clouds and Precipitation. D. Reidel Pub. Co.
4. E.M. Purcell, and C.R. Pennypacker, 1973: "Scattering and absorption of light by nonspherical dielectric grains," The Astrophysical Journal, **186**, pp. 705-714.
5. K. Umashankar, and A. Taflove, 1982: "A Novel to Analyze Electromagnetic Scattering of Complex Objects," IEEE Trans. Electromagnetic Compatibility, **EMC-24**, pp. 397-405.
6. P.C. Waterman, 1969: "Scattering by dielectric obstacles," Alta Freq., **38**, pp 348-352.

Figure 1. Depiction of the computations which lead to polarimetric quantities such as reflectivity factor at horizontal polarization Z_h, differential reflectivity Z_{DR}, specific differential phase K_{DP} (i.e. the difference in phase shift per km between horizontally and vertically polarized waves) etc.



BIO

Dusan S. Zrnic (born in Belgrade, Yugoslavia, Dipl. Ing. degree in EE University of Belgrade 1965, MS in EE 1986 and Ph.D 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.

FINDING FILES ON INTERNET

Randy J. Jost
SRI International
1611 N. Kent St.
Arlington, VA 22209-2192

Recap & Overview

In the last article, we "discovered" the Internet and found that it has many capabilities. Next to providing a conduit for E-mail, one of the most useful is the ability to download and/or transfer files from machine to machine. This capability alone is worth having the Internet access. However, this begs the question of "How do I find out WHAT is out there?" Equally important, assuming I know what I want, WHERE do I find it? The objective of this article is to help you find the files you may be looking for.

Finding Files

There are a couple of approaches to the art of finding and downloading files. The easiest, of course, is to find someone that is using software similar to what you want or need. Then you ask them to point you to where you need to go, complete with directions. Often, they will point you to a nearby users group or a local bulletin board system (BBS). If you don't have someone to get you started, then you can try the "tourist on a vacation with no schedule approach". If you are just looking for anything that might be interesting, then your best bet is to look over several of the archives that store files for your particular machine. In the last article, several of these sources were listed. To recap, the following sites are excellent places to start:

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

If you are on a "tighter schedule" or looking for specific types of files to download, but don't know where they might be or what they are called, then you need a little bit more of a hand. Given the fact that there are literally thousands of ftp sites, each potentially containing thousands of files, the task seems somewhat overwhelming. Fortunately, others have been down this path before, and there is an automated "phone book" that will help you "let your fingers do the walking".

ARCHIE

Archie is the name of an Internet archive server listing service, maintained by the Computer Science Department of McGill University, in Canada. The following information will provide an overview of what Archie can do for you. NOTE: Most of the following information is taken from the help files maintained on the archie database. This is the information you would get if you gave archie the "about" command.

Archie is a pair of software tools: the first maintains a list of about 1000 Internet ftp archive sites. Each night, software executes an anonymous ftp to a subset of these sites and fetches a recursive directory listing of each, which it stores in a database. We hit about 1/30th of the list each time, so each site gets updated about once a month, hopefully balancing timely updates against uncecessary network load. The "raw" listings are stored in compressed form on archie.mcgill.ca(132.206.2.3), where they are made available via anonymous ftp in the directory archie/listings.

The second tool is the interesting one as far as the users are concerned. It consists of a program running on a dummy user code that allows outsiders to log onto the archive server host to query the database. This is in fact the program we can "archie".

Users can ask archie to search for specific name strings. For example, "prog kcl" would find all occurrences of the string "kcl" and tell you which hosts have entries with this string, the size of the program, its last modification date and where it can be found on the host along with some other useful information. In this example, you could thus find those archive sites that are storing Kyoto Common Lisp. With one central database for all the archive sites we know about, archie greatly speeds the task of finding a specific program on the net.

Complete anonymous ftp listings of the various sites that we keep in the database may be obtained via the 'site' command and for a list of all the sites which we keep track of, see the 'list' command. For a list of all the archie servers worldwide, see the 'servers' command.

Archie also maintains a 'Software Description Database' which consists of the names and descriptions of various software packages, documents and datasets that are kept on anonymous ftp archive sites all around the Internet. The 'whatis' command allows you to search this database.

As of Jan 3 1992, the current archie servers included:

archie.mcgill.ca	(132.206.2.3)	McGill Univ.,Montreal, CANADA
archie.sura.net	(128.167.254.179)	SURAnet, College Park, MD, USA
archie.ans.net	(147.225.1.2)	ANS, New York, USA
archie.unl.edu	(129.93.1.14)	Lincoln, Nebraska, USA
archie.rutgers.edu	(128.6.18.15)	Piscataway, New Jersey, USA
archie.funet.fi	(128.214.6.100)	FUnet, Helsinki, FINLAND
archie.au	(139.130.4.6)	Deakin Univ., Geelong, AUSTRALIA
archie.doc.ic.ac.uk	(146.169.11.3)	Imperial College, London, UK
cs.huji.ac.il	(132.65.6.5)	Hebrew Univ., Jerusalem, ISRAEL

To interactively access one of the above servers, use telnet (or equivalent) to "call-in" to one of the above servers. When the connection is made, use "archie" (no capitals) for the user name. No password is required. Once you get in, type the word "help" for additional information. To put this into perspective, the above would result in the following ftp session from my location (Virginia, USA):

1. Log on to a host at your site that is connected to the Internet and is running software that supports 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. For those of you who need assistance, contact a local "System Wizard".

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

% ftp archie.sura.net

or

% ftp 128.167.254.179

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

Username: **archie**

Typically, no passport is required. At this point, you should get an archie prompt. For additional information, type help

archie>**help**

Currently, the available help topics are:

about	- a blurb about archie
bugs	- known bugs and undesirable features
bye	- same as "quit"
email	- how to contact the archie email interface
exit	- same as "quit"
help	- this message
list	- list the sites in the archie database
mail	- mail output to a user
nopager	- *** use 'unset pager' instead
pager	- *** use 'set pager' instead
plans	- future plans for archie
prog	- search the database for a file
quit	- exit archie
servers	- display a list of all currently available archie servers
set	- set a variable
show	- display the value of a variable
site	- list the files at an archive site
term	- *** use 'set term...' instead
unset	- unset a variable
whatis	- search for keyword in the software description database

For information on one of these topics type:

help <topic>

A '?' at the help prompt will list the available sub-topics.

For those that do not have an FTP capability, archie also has an E-mail interface. To access the email interface, mail to

archie@archie.mcgill.ca

For the body of the message, use the word Help. This is a completely automated interface, untouched by human hands, and information will be returned to you detailing how to use archie in an E-mail or batch mode.

Finally, if you need to send a message to a real person, general comments, suggestions, cries for help, etc. can be sent by E-mail to:

archie-l@archie.mcgill.ca

Downloading Files

Once you have located the files you think you want, you can download them, following the procedures given in the last article. As an alternative, you can use archie to E-mail you the files you are looking for. However, use of this approach is somewhat dependent upon the mail package you have installed at your site. Some of them tend to "choke" if they receive a mail message larger that 30-45 Kb. Even with regular ftp capability, large files can be a problem, both in terms of connect time and in storage. To get around this somewhat, the files stored on the network servers tend to be compressed with one of a myriad of data compression formats. Generally speaking, files downloaded in these formats are NOT directly usable by a machine's native Operating System. One exception to this is the "text" file, usually a plain vanilla ascii file with text characters. Most text files are indicated by the extension ".txt".

Since each server uses a format that is dependent upon the machine the files are stored on (UNIX, VAX/VMS, Workstation, etc.) the target machine of the file (Macintosh, DOS, UNIX) and the type of file that is stored (ascii, binary, text, executable, etc.). Because of the diversity of machines and formats, this is a fairly complicated topic. In fact, to treat it adequately, we'll leave it for next time.

Summary

Although there are many approaches to finding files and software on the Internet, the best approach is to use the program archie. Through the use of archie, you can find out what sites are accessible by ftp, what is at a given site, or find out what sites have a given file. In the next part of this tutorial, we'll cover the topic of file formats and how to convert from compressed files to files usable by a machine's native operating system.

For Further Information

1) "The BMUG Guide to Bulletin Boards and Beyond" by Bernard Aboba. Available for $20 (+$4.00 S&H) from BMUG Inc., 1442A Walnut St. #62, Berkeley, CA 94709. Phone (510)549-2684; FAX (510)849-9026. **NOTE: This phone number is a correction from the one listed last time.**

2) "The Matrix: Computer Networks and Conferencing Systems Worldwide" by John S. Quarterman, Digital Press, 1990. This book gives an extensive overview of the major (as well as most minor) networks around the world and how they tie into each other. Lists most networks that are part of the Internet, as well as many examples of networks that are NOT part of the official Internet.

3) The archive sumex-aim.stanford.edu maintains several files in the subdirectory "report" that contain information about the Internet, ftp sites, and the downloading of files. Several of these have provided information for this series of articles. Among these are the following:

info-mac/report/compression-util-table.txt
info-mac/report/e-mail-gateways.txt
info-mac/report/ftp-primer.txt
info-mac/report/ftp-sites.txt
info-mac/report/how-do-i-find.txt
info-mac/report/internet-access-11.hqx
info-mac/report/internet-acronyms.txt
info-mac/report/internet-dial-in.txt

Although this archive is oriented towards Macintoshes, these are all text or ascii files, and are readable by non-Macintosh machines as well.

BIO

Randy J. Jost is a Program Manager for SRI International, located in the Washington DC office. When he was on active duty with the U.S. Air Force, he taught at the Air Force Institute of Technology and also served in the Wright laboratories, both located in Dayton, OH. Currently, he is still a Major in the Air Force Reserve. He has also taught at the University of Missouri-Columbia and at Wright State University. While in Dayton, he was active in the local IEEE sections of the Antenna and Propagation Society and the Electromagnetic Compatibility Society. His major interests are in the application of mathematical and numerical techniques to various areas of electromagnetics, including the prediction and modification of radar cross section, microwave engineering, and lightning & EMP interaction with aircraft. Other interests include Amateur Radio (N8NAZ) and working (playing) with his Macintosh.

ACES Database - An Update

The ACES E-mail "database" is slowly accumulating names. To date, the following individuals have contacted me about becoming part of the database. The full information (name, address, phone numbers, interests, etc.) is stored at my location on computer (Macintosh), using Filemaker Pro. I can make this information available to those who use this package or have a database package that uses one of its output formats (Tab-Separated Text, Comma-Separated Text, SYLK, DBF, DIF, WKS). For those that don't yet have access to E-mail, or a database package. I can also print up a "report" that contains the basic information. Requests for information, additions, or corrections to the information below should be sent to Randy Jost, (E-mail number below) or by snail mail to:

Dr. Randy J. Jost
SRI International
1611 N. Kent St.
Arlington, VA USA 22209-2192
Phone (703)247-8415
FAX: (703)247-8537

NAME	E-MAIL ADDRESS
Richard W. Adler	5541304@mcimail.com
David Angst	angst@tcad.infocomm.com
Tim Aubrey	timaa@ee.uts.edu.au
Chalmers Butler	cbutler@eng.clemson.edu
Alan R. Clark	CLARK@odie.ee.wits.ac.za
Duncan C. Baker	elo0004@upvm2.up.ac.za
David B. Davidson	DAVIDSON@firga.sun.ac.za
Marc Dion	marc@eds.ed.dreo.dnd.ca
Paul Elliot	Paul@apti.com
Jeff Fath	jeff_fath@qm.mbvlab.wpafb.af.mil
Todd Hubing	thubing@ee.umr.edu
Shian Hwu	HWU@tcd.jsc.nasa.gov
Randy J. Jost	jost@wdc.sri.com
Jim Logan	logan@nosc.navy.mil
Robert C. Mallalieu	mall@aplcomm.jhuapl.edu
David P. Millard	dmillard@gtri01.gatech.edu
Osama A. Mohammed	ulerf@servax.fiu.edu
Gerrit Mur	G.Mur@ET.TUDelft.NL
Barry Ornitz	ornitz@kodak.com
Robert Paknys	paknys@alcor.concordia.ca
Robert Pinto	pinto@ssl.tasc.com
John Rockway	rockway@nosc.navy.mil
Daniel P. Roesler	droesler@Sparc3303.CACD.CR.rockwell.com
David A. Rogers	drogers@plains.NoDak.edu
Hal Sabbagh	has@sabbagh.com
Kenneth R. Siarkiewiczk	siarkiewiczk@lonex.rl.af.mil
Eugene Tomer	etomer@netcom.com
Scott Townley	scott_townley@smtp.esl.com
Miles Upton	megu@camcon.co.uk
Edward Urbanik	urbanik%ncavax.dnet@rapnet.sanders.lockheed.com
Frank Walker	Walker@atomic.Boeing.com
Perry Wheless	wwheless@ualvm.ua.edu
Keith W. Whites	whites@engr.uky.edu
Debra Wilkes	dlwilkes@sunrise.acs.syr.edu

WORKSTATION AND COMPILER COMPARISON FOR NEC

Paul Elliot
ARCO Power Technologies, Inc.
1250 24th Street, NW Suite 850
Washington, DC 20037
E-mail: paul@apti.com

Part I of this article compares several computers as possible NEC workstations. Part II compares compilers available for NEC on an IBM compatible workstation.

I. WORKSTATIONS

Several computers are compared as possible NEC workstations. Due to the large FORTRAN arrays generated by large NEC problems (described in July 1992 Newsletter) only computers that could use more than 128 MB of RAM were considered. Without a large amount of RAM the computation is slowed down very much by paging to disk.

Table 1 lists several workstation options. In addition to the processor, the cost shown below includes a 500 MB or larger hard drive, monitor, operating system, a FORTRAN compiler, 128 MB of RAM at $40/MB which is the approximate price offered by 3rd party vendors. The double precision Linpak benchmark Mflops shown for the IBM RS 6000 and the 486 are from a list showing test results for many computers available from Prof. Jack Dongarra, Univ. Tennessee, (615)974-8295. The Mflops for the HP and SUN are dealer claims reduced by 25% to be more comparable with independently confirmed testing. The last column is a measure of the dollars paid per megaflop.

TABLE 1. WORKSTATION COMPARISON

Computer	Cost	Linpack Mflops	k$/Mflop
HP 9000/750	$53k	24	2.0
IBM RS6000/530H	$48k	20	2.4
SUN Sparcstation10	$33k	13	2.5
486DX2-66	$10.6k	2.5	4.2
486DX-50	$9.6k	2.1	4.6

Not all FORTRAN compilers can handle NEC2, so it is highly advisable to make sure that NEC will compile and run before buying the computer. In addition to the cost, raw speed, and compiler concerns already mentioned, other considerations are the number of other users on the system, learning curve for the operating system and system management functions, suitability to other desired applications, availability of other software and peripherals, vendor support, and networking capability.

Several 486DX-50MHz and 486DX2-66 IBM-PC compatibles can install 128 MB of RAM on the motherboard and can use even more system RAM on add-in memory cards when these cards become available. These 486 vendors include NOVACOR (408)441-6500, Future Tech (800)275-4414, International Instrumentation (800)543-3475, and Polywell (415)583-7222.

Some other platforms offer considerably more cost-effective k$/Mflop than those listed above but the amount of system RAM accessed is limited to 128 MB or less. These include the Hewlett- Packard 9000/HP 710, HP 720, HP 730, add-in accelerator boards based on the i860 chip such as the Microway i860 and i860XP, and add-in boards based on the T805 chip. Some other options to be available in early 1993 are the P5 or P6 (i.e. 586 & 686) based sucessors to the 486, and the DEC Alpha machine.

II. UPDATE ON COMPILER SPEED COMPARISON

In the March 1992 issue of the *ACES Newsletter* I compared NEC2 run times using the Microway and Lahey FORTRAN compilers. A new comparison is reported here using the new version 5.01 of the Lahey compiler. The speed comparisons shown below do not conclusively demonstrate either compiler to be faster.

Some other FORTRAN compilers for IBM compatibles are described in the article by Konrad et. al. in this issue but without speed comparisons. Also, the list of Linpack benchmarks from Jack Dongarra mentioned above shows that, using the same computer, the Microway 486 compiler (version not given) may be about 15% faster than the Salford or Watcom compilers. 15% difference in the Linpack may not be significant given the range of speeds shown below in Table II for different NEC problems.

A more recent version exists for the Microway compiler than the version 3.1 used for all the tests reported in Table II, but these more recent Microway versions cannot sucessfully run the NEC2 source code. Microway expects that problem to be fixed in the next couple of months so that version 4 of the Microway compiler might outperform the version 3.1 results shown below.

The computer used was a 486-33 MHz EISA Micronics IBM compatible motherboard with 64 MB RAM, a 500 MB Maxtor SCSI-2 hard drive with Bustek 740A SCSI-2 controller, and a Weitek math coprocessor. Two NEC2 test input files were used. Test #1 used the 101 segment NEC2 input file shown below which is the same input file used for the March 1992 Newsletter article except the number of frequencies has been increased. Test #2 consisted of a 2112 segment geometry in 4 symetric sections at one frequency. The 2112 segment input file is not shown due to its length but can be provided to any interested readers. For all these runs NEC2 was compiled to accomodate 3200 segments and a maximum matrix size of 1600 by 1600 segments.

```
CE   TEST #1   NEC2 INPUT FILE.   101 SEGMENTS
GW   1 101    0. 0. 0.    0. 0. .5    .0001
GE
EX   0  1  51    00    1.     0.
FR   0 10  0     0     250.   10.
EN
```

The Lahey compiler is FORTRAN F77L-EM/32 version 5.01 with version 4.1L of the Phar-Lap DOS Extender. Microway makes a 386 version and a 486 version of their version 3.1 compilers. Both were tested using the 486 machine described above. Microway also provided a choice of which DOS extender to use: the PharLap (v2.2) or the NDP Tools DOS extender.

The resulting run times are shown in Table II. The 8 cases tested are the two NEC input files, single or double precision NEC2, and with Weitek switched on or off. The run times are all between 1.00 and 1.50 since they are normalized to the time shown for each row. The run time includes loading the program and for the compiler to complete whatever housekeeping it requires to get ready to run.

TABLE II. NEC2 RUN TIMES

Single Dble Prec.	NEC Input #Seg	Weitek	Minutes Used to Normalize	NORMALIZED RUN TIMES Microway Compiler v.386 PharL	v.386 Tools	v.486 PharL	v.486 Tools	Lahey Compiler
S	101	ON.	26.48 min	1.02	1.02	....	1.06	1.37
S	101	OFF	26.48 min	1.20	1.06	1.32	1.17	1.00
S	2112	ON	36.73 min	1.00	1.04	....	1.07	1.31
S	2112	OFF	36.73 min	1.16	1.16	1.38	1.15	1.20
D	101	ON.	34.25 min	1.13	1.22	....	1.24	....
D	101	OFF	34.25 min	1.19	1.00	1.30	1.11	....
D	2112	ON.	47.65 min	1.28	1.38	....	1.37	....
D	2112	OFF	47.65 min	1.24	1.19	1.47	1.22	1.00

Since the Lahey runs faster for some cases and the Microway for others, its a toss-up which is better for NEC. In my opinion Lahey is somewhat easier to use with better error messages and slightly better documentation. Lahey also compiles faster, but crashed on one of the NEC cases.

Some general conclusions can be drawn from Table II which are valid for most but not every case. The $900 Weitek did not help the Lahey compiler running on a 486. Lahey says this is because the 486 comes with a built-in 487 math coprocessor which is faster (for Lahey) than the Weitek, but if I had a 386 machine then the Weitek would help. The Weitek only helps the Microway compiler in single precision. The Microway Tools is faster than the Microway PharLap without a Weitek, but the reverse is true with a Weitek. Weitek Corporation says they have no plans to manufacture coprocessors for 486 computers running at 50 MHz or faster, now or in the future, because they cannot improve much on the speed of the built-in 487 coprocessors at those clock speeds.

The Microway v.386 compiler runs faster than the Microway v.486 compiler, even though it was running on a 486 machine! Microway technical help did not sound terribly surprised to hear this for version 3.1, and said that when their more recent compilers are improved so they can be used with NEC then the 486 versions should outperform the 386 versions.

Not all cases would run as shown by the ". . . . " entries. The Lahey compiler does not support the Weitek for double precision complex arithmetic. Lahey was also unable to run one Weitek off case giving an "invalid number, 0/0, or integer overflow" error message. This was a recurring problem for large double precision NEC runs using Lahey. The Microway v.486 using PharLap crashed for all "Weitek On" runs giving a "memory protection fault error" which may be a bug in my motherboard or Weitek chip since I have had occasional other problems with my Weitek.

In addition to working in DOS, both Lahey and Microway claim to run in a DOS window of OS/2 and Windows 3.x. The big advantage of this is that NEC will then run in the background while you can still use your computer to do something else. I have verified this using NEC2 for Lahey but have not tried it for Microway. The speed is halved when doing this in Windows 3.x, but not OS/2 since OS/2 (and Windows NT) are true multitasking operating systems.

Both compilers come with a debugger and DOS extender at no additional charge. The Lahey Compiler costs $1195 and will run on a 386 or 486. The Microway compiler costs $995 for the 486 version or $695 for the 386 version. Both the 386 and 486 compiler versions will run on either a 386 or 486 machine, the difference is said to be the speed. But as shown in Table II, the 386 version seems to be actually faster for NEC than the 486 version, even on a 486 machine. This may soon change if Microway enables their more recent version 4 to run NEC. Microway claims that for version 4, the 386 version is much slower on a 486 machine with a Weitek than the 486 version. With no Weitek on a 386 machine they say the 386 version is about as fast as the 486 version.

The Lahey switches used are the following. Weitek on (switches /4 /k -Weitek on) and Weitek off (switches /4 /nk -Weitek off) were both tested. The /Z1 optimization switch was also tried for one Lahey case but made no significant run time difference since the time was less than 0.30 % slower. /nZ1 was then used for the results shown in Table II. However the list of Linpack benchmarks by Prof. Dongarra mentioned above shows a 17% speed increase using the Lahey /Z1 switch. The -pack linker switch was used for Lahey.

Microway switches used were the -OM and -on optimization switches and -v. The -exp and phar2 switches were also used with Phar Lap. The -n4 -n7 -n8 were used with Weitek on. -n3 was used with the 386 versions.

The NEC2 test cases which were used for earlier runtime comparison described the March 1992 *ACES Newsletter* were also rerun. Those were short 1 or 2 minute NEC runs. The Lahey ran faster than before which I would attribute to the compiler upgrade. However, to my astonishment I found that the run times had slowed greatly for the Microway compiler v.3.1 even though I was using the same compiler version, switches, and DOS extender, but had recompiled NEC2 on a new hard drive. Larger NEC2 problems (taking one or more hours) run at the same approximate speed as before. Microway technical support said the most likely cause of this speed change was the different type of hard disk controller cache I now have (SCSI instead of ESDI) and possibly more time to set up the swap file on the hard drive. At that point I concluded that run time comparisons for run times on the order of 1 minute are too variable to be very useful. The preceeding comparison is therefore done with NEC2 problems that run 25 to 70 minutes.

THE IBM PC AND COMPATIBLE USE FOR ELECTROMAGNETIC ANALYSIS

A. Konrad[1], J. Bigeon[2], K. Preis[3],
I. Bardi[3], B.F. Colyer[4], J.D. Lavers[1],
J.C. Sabonnadiere[2] and K.R. Richter[3]

[1]Dept. of Elec. Eng., University of Toronto, Toronto, Ontario, Canada, M5S 1A4
[2]Lab. d'Electrotechnique de Grenoble, ENSIEG, 38402 Saint-Martin d'Heres, France
[3]IGTE, Technische Universitaet Graz, Kopernikusgasse 24, A-8010 Graz, Austria
[4]Vector Fields Ltd., 24 Bankside, Kidlington, Oxford OX5 1JE, England

Abstract - The paper describes the authors' experience with IBM PC compatible computers. Two particular aspects of software needs are examined: big Fortran programs and graphics. The paper discusses the system software, compilers and graphics routines required to make the PC a useful tool for electromagnetic software developers and users.

I. INTRODUCTION

The capabilities of IBM PC and compatible computers have improved significantly in recent years. Indeed, the power and affordability of presently available models are as impressive as is the miniaturization that these machines have undergone. Today, it is not uncommon to find even notebook class PC's that use the Intel 80386 or 80486 processor, incorporate several megabytes (MB) of memory and have a high speed 40 - 120 MB hard disk. There is a choice of different operating systems for such machines, including DOS, WINDOWS, OS/2 and UNIX. Similarly, programs can be written in a variety of languages including Turbo Pascal, C, Basic and Fortran, among others. In this paper, only DOS and OS/2 will be considered as an operating system and only Fortran will be considered as a programming language.

This paper is addressed to researchers who are considering the use of one of the newer power-PC's as a development platform for large electromagnetic field analysis programs. Even at the purchase stage, they may find that the most knowledgeable computer hardware and software sales people are of little help in the area of scientific computing, particularly the use of Fortran on a PC. Additionally, while graphics packages for the PC are available in most computer stores, they are generally not of the Fortran callable type.

The material that follows is intended primarily for the 'old-fashioned' Fortran programmer who wants to make good use of his PC without 're-education'. It is based on the experiences of three university research groups and one electromagnetic field analysis software company. The reader should obtain a clear idea what is needed to run large Fortran programs on a PC. While all the information can be found in various manuals and software documentation, consolidation and digestion can be a long and agonizing process. The authors hope that this paper provides a suitable shortcut.

II. HARDWARE REQUIREMENTS

The cheapest processor which might be worth consideration today is a 386SX in a notebook computer. However, an intending purchaser who wishes to run large electromagnetic programs would be well advised to buy a machine with at least a 368DX processor and preferably a 486DX. In a 386-based machine, a numerical coprocessor is mandatory if reasonable execution speed is desired; The 486DX includes the numerical coprocessor but the 486SX does not. The minimum processor clock frequency is 25 MHz, with 33 or 50 MHz being strongly recommended.

The absolute minimum of Dynamic Random Access Memory (DRAM) which should be fitted is 2 MB, although one of the compilers described below may be able to function with less. However, more memory is always advantageous and since the price of memory chips has been dropping steadily, it may be reasonable to install more than 16 MB of RAM if very large arrays are used. Cost may or may not be significant depending on funds available.

The requirement for hard disk is mainly dependent on the software which one will want to have available. Most users of 386 machines running DOS will want to have Microsoft Windows 3 or 3.1 which will occupy up to 10 MB of hard disk. The latest version of the full OS/2 requires 30 MB of hard disk space. A Fortran compiler and its associated system may need 2 MB, while a good text processing package for composing reports and papers will require a further 3 MB of disk. Another 20-30 MB will be required for source code, executables, data and swap files. Consequently, a 60 MB hard disk is probably the minimum for a desktop PC and the recommended size is at least double the amount. Regarding hard disk access time, anything slower than 28 ms is likely to be unacceptable and 17 ms or faster is desirable.

The provision of a Microsoft compatible mouse should be considered as essential for a desk top machine.

III. COMPILER REQUIREMENTS

Certain considerations may well determine the choice of Fortran compiler. Some questions worth asking are:

(a) How many lines per minute can be compiled?
(b) What run-time performance can be expected?
(c) What extensions to ANSII Standard Fortran are accepted?
(d) Is paging to hard disk supported? (A necessity for huge programs).
(e) Will the compiler recognize at run time what coprocessing capability is available? Is a Weitek coprocessor supported?
(f) Is software emulation possible for floating point calculations? One may want to use a program developed on a PC with coprocessor, on a machine without one. Will this require relinking with a different library?
(g) Is there an integral debugging system and how good is it? Does it support checking of array subscript errors and arithmetic overflow, display of variable values?
(h) What error and messages are generated during compilation and execution? Is it possible to suppress compilation error and warning messages?
(i) Are library subroutines available for (1) system access, (2) graphics, (3) accessing real mode programs and (4) hot key program (A resident program which may be invoked by pressing a previously defined 'hot key combination' such as Ctrl-Alt-H)?
(j) What graphics packages from other vendors can be used?
(k) Will it be possible later to link C and C++ code with the Fortran? C++ holds promise for the development of graphics user interfaces, though one might expect the bulk of application codes to remain in Fortran.
(l) What will be the licensing arrangements and cost should it be decided to market programs compiled and linked with the compiler? This is an important factor in making a choice. If compiler and DOS Extender (see below) come from different vendors, one may have to pay royalties to both.

IV. EDITING FILES

Operating systems such as DOS and OS/2 come with their own editors. While the older editors provided with DOS are virtually without merit, DOS version 5 and all versions of OS/2 come with simple editors that are much better and include on-line help and mouse support to perform editing functions like copy, paste, change, replace, multi-file editing, etc. The OS/2 editor also runs in a window. There are also excellent public domain or shareware editors that are available at little or no cost (e.g. LITE, GALAXY/LITE, EMACS). Finally, some compilers such as MS Fortran come with a built-in editor. In many cases (e.g. EMACS), the capabilities of the editor can be extended by programming them to perform new functions.

V. MEMORY MANAGEMENT UNDER DOS

To understand Fortran on a PC, one must first understand the basics of memory allocation for an Intel 80386 Central Processing Unit (CPU). The PC operating system DOS was designed to access an address space of 1 MB. The first 640 KB is known as "conventional or base memory" space: the lowest part of it is used for the operating system and installed device drivers; the remainder is available for user programs and data.

The remaining 384 KB, known as "upper memory", is used by various parts of the computer's hardware, such as the Video Display Adapter and the Basic Input Output System or BIOS, which interfaces the operating system to the 80386 processor. Depending on the hardware and the operating system, it may be possible to relocate device drivers into parts of the upper 384 KB memory which are not being used by the Video Display Adapter, etc.

The 80386 processor can address more than 1 MB. The first megabyte is accessed by putting the processor into a mode of operation known as "real". Memory above the first megabyte is called "extended memory" which is accessed by putting the processor into "protected" mode. To use protected mode requires the use of a suitable operating system such as OS/2 or UNIX.

Under DOS, the 386 can only work in real mode because DOS uses 20-bit addresses which can only access 1 MB. However, it is possible to access memory above 1 MB by providing a suitable driver program; the executing program communicates with the driver and the driver reads from or writes to the memory above 1 MB.

The driver program is known as a "DOS Extender" and there are a number of such programs available; an Extender suitable for a given Fortran compiler may be written by the developers of the compiler (e.g. the Salford compiler) or obtained from an independent vendor (e.g. the Phar Lap Extender used with Lahey, NDP and Watcom Fortrans). The use of an Extender means that a program can use 32-bit addresses which can access up to 4 gigabytes (GB) of memory.

The behaviour of a typical DOS Extender is as follows. The user will start the Extender, either by explicit command or by incorporating a suitable line in the AUTOEXEC.BAT file. When a program starts execution, all the free memory below 640 KB and the free extended memory above 1 MB is divided into 4 KB long pages. These pages provide virtual memory. It may be possible to increase the pool of pages by swapping to a partition or file on the hard disk. The Extender may be able to relocate most of itself above the first 640 KB which leaves more space available for real mode programs which one wishes to run at the same time (one example would be the editor which one uses for editing the Fortran source code). Compiler manuals may mention the term "high memory" which is often taken to mean the first 64 KB of extended memory and is usually available to only one program or piece of code. For example, Digital Research's DR-DOS is able to relocate the main operating system kernel into this 64 KB.

VI. MICROSOFT FORTRAN UNDER DOS

When shopping around for Fortran compilers one quickly discovers that the choice is limited. The best known but not necessarily the best PC Fortran compiler is Microsoft Fortran Version 5.1. This compiler comes with 1590 pages of documentation [1-6]. If one is already familiar with Microsoft Fortran, the documentation is useful. However, as with most computer software documentation, a novice user may take a while finding exactly what she or he is looking for.

The Microsoft Fortran Version 5.1 compiler works under both DOS and OS/2 but it must be configured and installed specifically for one operating system or the other. Installation under DOS is not recommended if the intention is to run large Fortran programs which can access more than 1 MB of memory. If one decides to use DOS, the solution may be either the Lahey F77L-EM/32 Fortran compiler with the Phar Lap Extender or the University of Salford FTN77/386 or 486 Fortran compiler. There are other compilers of this type also available (e.g. Watcom and NDP Fortran) but the authors' experiences are limited to the Microsoft, Lahey and Salford compilers.

VII. USING THE LAHEY FORTRAN COMPILER

The Lahey/Phar Lap DOS Extender is necessary for the execution of programs compiled with the Lahey F77L-EM/32 v.5 Fortran compiler [7,8] and allows the user to address as much as 4 GB of virtual memory. To work with the Lahey/Phar Lap Extender, a kernel has to be started. The name of the kernel is RUN386.EXE for both non-virtual and virtual memory. To start a program in protected mode, the command 'run386 Program Name' has to be typed. The run386 System is in the C:\F77L3\BIN directory.

The Lahey F77L-EM/32 compiler and 386LINK linker are real 32-bit tools. The F77L-EM/32 Fortran is an extension of standard Fortran 77. One can use large arrays without any special measure. The allocate and deallocate commands, shown in the example below, make it possible to obtain relatively small executable codes:

```
real*8 var(:)
allocatable :: var
...
isize=1000000
allocate  (var (isize))
...
diallocate (var)
```

The compiler stored under file name F77L3.EXE has several options. The options can be specified either by switches typed after the name of the compiler or by running a special configuration program called FIG3.EXE which creates a compiler configuration file called F77L3.FIG.

The Lahey Linker, stored under file name 386LINK.EXE, operates in protected mode and is invoked by the command '386link Program' The linker creates a file with a .EXP or .EXE extension depending on switch setting.

The use of the make utility command is similar to that under the UNIX operating system. Both compilation and linking are processed with the automatic update monitoring by using a make file which should start in the following way:

make - f "makefilename".mak

It is assumed that every necessary path is set. Note that capital letters cannot be used!

The Lahey Fortran compiler is VAX compatible but there is a difference in the physical record length of the data. The record length of a data file must be given in bytes instead of 4-byte units when Direct Access Files are used.

VIII. THE SALFORD FORTRAN COMPILER

This compiler [9] has been used successfully by Vector Fields Limited to transport electromagnetic software to the PC. Two versions of this compiler are marketed: FTN77/386 and FTN77/486. The latter is somewhat more expensive, but produces better code for 486DX machines on which FTN77/386 compiled programs run slower. However, FTB77/486 programs run just as well on a 386 machine as do programs compiled with FTN77/386, so the small additional cost is probably worthwhile.

The DOS Extender, written by Salford, is known as DBOS. It can be run directly under DOS or by means of a small interface program called WDBOS under Windows 3 running under DOS. DBOS can be configured either to page in DRAM only, or to page to both DRAM and a hard disk - either a dedicated hard disk partition or a hard disk file. Thus the size of one's program is limited only by the hard disk space which one is able to allocate or purchase. DBOS recognizes what coprocessing facilities, if any, are available. When not running under Windows 3, DBOS may be configured to provide hard disk caching which can reduce delays due to disk input/output; Windows 3, however, provides its own disk caching option. To the user of the compiler it appears as though a linear address space of up to 4 GB is available. It is not necessary to choose from a number of memory models.

The system consists of the compiler itself, ftn77, and a linker named link77. A make facility, similar to that of Microsoft Fortran or UNIX, is provided. Link77 may be used interactively, and it can be driven by command files which provide the names of the object files to be linked. Both methods may be used together. When compiling, it is assumed that Fortran source files have the extension .for, unless explicitly specified otherwise (this avoids renaming files with .f extensions transferred from a UNIX system).

A simple program contained in a single file can be compiled and executed with a single command:

```
ftn77 myprog /lgo
```

The following example demonstrates the compilation of several files, and the process of linking the resulting object files together with a library containing object files:

```
> ftn77 main.f
> ftn77 sub1
> ftn77 sub2
> link77
$ load main
$ load sub1
$ load sub2
$ load mylib
$ file myprog
```

where > is the DOS prompt and $ is the link77 prompt. The source files are named main.f, sub1.for and sub2.for. The object files and the library all have the .obj extension. The 'file' command writes the final executable program file myprog.exe. However, it is usually more convenient to use .bat files, or makefiles with the make utility to compile and link large numbers of program files.

Two kinds of libraries are supported: (1) relocatable binary libraries and (2) dynamic link libraries. Relocatable binary libraries are prepared by using a utility named mklib77, e.g.

```
> copy sub1.obj/b+sub2.obj temp.obj
> mklib77 temp.obj mylib.obj
```

Mklib77 also provides an interactive mode.

Dynamic link libraries are linked to the program by DBOS at run-time. This allows .exe files to be kept small and provides the advantage that a library will be searched recursively until all references have been satisfied. This does not happen with relocatable binary libraries where the ordering of routines in a library is important. A dynamic link library is created with the link77 utility, for example

```
> link77
$ liboffset 41000000
$ load mylib.obj
$ file mylib.lib
```

The hexadecimal number following the liboffset command is the address at which code in the library will run; this is arbitrary but must be at least 4095 bytes beyond the last address used by the program.

IX. MICROSOFT FORTRAN UNDER OS/2

OS/2 is a multitasking operating system which is philosophically quite different from DOS. Under OS/2 the CPU operates in protected mode. Thus programs can access all available memory without employing special driver programs. For those who have been used to systems such as VMS or UNIX, DOS may be somewhat uncomfortable. For example, DOS commands such as 'del' accept only one argument and wild cards do not always work. OS/2 commands, on the other hand, usually allow multiple arguments as well as wild cards. A common feature of DOS and OS/2 is that both systems have CONFIG.SYS and AUTOEXEC.BAT files. For programs that run only under DOS, the DOS window allows one to run DOS real mode programs under OS/2.

In order for MS Fortran to function under OS/2, the CONFIG.SYS file must contain the following

```
protshell=/k c:\os2\init.cmd
set path =c:\fortran\bin
libpath  =c:\fortran\bin
```

The file init.cmd in the c:\os2 directory contains initializations for the Fortran compiler:

```
set include=c:\fortran\include
set init    =c:\fortran\bin
set lib     =c:\fortran\lib
set tmp     =c:\fortran\tmp
```

The important MS Fortran compiler files are in the libraries bin and lib. The setup program also creates the include and tmp libraries. The fl.exe file corresponding to the "fl" Microsoft Fortran command is in the bin directory.

Microsoft Fortran comes with 59 different options to cover every possible situation for the fl command. This is sufficient to scare even the most seasoned Fortran programmer. A user who just wants to compile, link and run his large program may spend a substantial amount of time before he hits the right combination. To use this command without having to remember all the necessary options, one can create the following f77.cmd command file

```
@echo off
fl /FPc /AH /Gt49 %1
```

The /FPc Floating Point Option causes the compiler to generate floating-point calls and select an emulator math library if a math coprocessor is not present. A nice feature of this compiler is that the executable code automatically detects the presence of a math coprocessor. The math libraries available with /FPc are either llibfore.lib or mlibfore.lib depending on the memory-model option used.

There is an excellent expose of what a Memory Model is in chapter 2 of the Microsoft Fortran Advanced Topics manual [4]. The main reason for the existence of Memory Models in MS Fortran is the segmented architecture of the Intel 8086 family of processors from which the 80386 derives. Another reason is the infinite wisdom of compiler writers to give the user control over all the possibilities that such an architecture provides.

One must recall that the 8086 processor and its family are 8-bit computers which can access maximum 64 KB of memory. To extend the amount of physical memory that can be reached by a program beyond the 64 KB limit, the memory is divided into 64 KB segments. Addressing can be performed on two separate levels; In some cases a 16-bit so-called near address is sufficient to locate the beginning of a 64KB segment and all items in it; In other cases a complete 32-bit so-called far address is required to locate both the beginning of a segment and one of the 65536 items in it.

The subject of addressing is further complicated by the fact that both program and data must be stored in memory and they each may occupy multiple segments. Why do compiler writers worry about near and far addressing? Because instructions with 16-bit near addressing are faster than instructions with 32-bit far addressing. A program which is stored in multiple memory segments will be less efficient than a program that fits into a single 64 KB segment because all subroutine and function calls will be carried out with 32-bit far addresses. Similarly, data items that exceed 64 KB must be accessed exclusively by far addresses.

If one is only interested in large Fortran programs using huge data arrays, then the only Memory Model of importance is the Huge Memory Model. Since the speed of a 80386 far exceeds the speed of a 8086, a Fortran user today is less interested in the internal addressing efficiency of the CPU. /AH in the command line above is the Memory Model Option which causes the compiler to choose the huge memory model corresponding to the llibfore.lib math library located in the lib directory.

Without the /Gt49 Data Threshold Option a novice user of MS Fortran will sooner or later encounter difficulties when compiling and linking huge programs. Although a description of this option is given in [3] (pp.326-327) and a reference to it is made in connection with the default data segment in [4] (p.28), it is not at all easy to understand it for someone who is not familiar with the jargon. For instance, what is the significance of 49?

With large programs, it is possible to encounter a problem in MS Fortran due to the way character table addresses are being manipulated by the linker. The MS Fortran compiler places character type data in a single default data segment limited in size to 64 KB. In the case of big programs the 64 KB is usually too small. It is in such cases that one must use the /Gtxx option which instructs the compiler and linker to place character variables longer than xx characters in other data segments. The /Gt49 option instructs the compiler and linker to place only character variables which are less than 49 characters long into the 64KB default data segment. All other longer than 49-character character-variables are placed in other 64 KB data segments. For really huge codes, in conjunction with the /Gt49 option, one might also have to use the /SE option followed by 1024 as the total number of data segments allowed.

The above f77.cmd command file works very well and with multiple arguments as long as the number of subroutine names fit on a line which is maximum 256 characters long. But what if the line is longer? Computer manuals notoriously omit obvious items such as command line continuation. In OS/2 such a thing simply does not exist. The solution is to use the 'nmake' command (nmake.exe is in the bin directory).

To compile and link a hundred or so Fortran subroutines, each stored in a separate file, and a main program called progname.for located in directory, one should issue the following simple command:

```
nmake @cmmdline
```

Two files must be present for this command line to work properly:cmmdline and makefile. The former contains all the arguments of the MS Fortran nmake command:

```
/f makefile /x erorfile directory
```

Obviously, one of the 'nmake' arguments is 'makefile' which contains the following lines:

```
directory: *.for
f77 *.for
del *.obj
ren *.exe progname.exe
```

The 'makefile' instructs 'nmake' to use 'f77.cmd' to compile all files in 'directory' with the .for extension. After compilation, all files with the .obj extension are deleted. Since nmake insists on compiling and linking all the subroutines in alphabetical order, the executable file bears the name of the alphabetically first subroutine. This is the reason for the last line containing a rename instruction. After every compilation there is an 'erorfile' created which may contain compilation error messages.

X. GRAPHICS AND FORTRAN

Some of the available compilers offer useful graphics features. This is certainly the case with the Microsoft and Salford compilers. However, such features are not standardized in any way and code which uses them is specific to a particular compiler.

For example, the Salford compiler provides a set of PC graphics calls, together with hardware and Hershey fonts. These are pixel-based, so the user must take care of scaling and transformations. If the user wishes to write code which is portable between different compilers, or prefers access to a system which takes care of problems such as scaling, different screen resolutions, etc., then a specialized graphics library must be obtained from another vendor. Certain such graphics libraries may be used on a wide variety of machines, ranging from mainframes through workstations to PC-s. Typical of such libraries are GSS, INTERACTER and GKS. These are available compiled with Salford and Lahey Fortrans, hence run with 32-bit addressing via the appropriate DOS Extender.

Consider as one example INTERACTER, a library of subroutines which aims to provide programs that can be ported without alteration of code or functionality over a wide range of makes of machine. This may be somewhat of a disadvantage to the PC programmer since the set of provided functionalities is necessarily that which is common to the sets of functionalities for all the supported machines. Nevertheless, the package provides almost all the functionality which the PC can handle, including window management, forms, high resolution graphics and presentation graphics. At the time of writing the notable exception is the use of the mouse to select from menus.

When using Lahey Fortran, the graphics may be processed by means of the Graphoria library [10]. This enables the Fortran programs to generate quality graphics output on video devices. A special driver is necessary for making a hardcopy or the program PIZAZZ can be used for this purpose. The library contains advanced line drawing, polygon filling, text and symbol writing, coordinate axes treating routines and the mouse is also supported. Unfortunately, different line widths and an automatic clipping are not a feature of the library. Another poor feature is that only a 640x480 resolution with 16 colours is available so far in a direct way. Higher resolution with more colours are available only via BIOS interface which makes the operation slow. There is a possibility to use a Trident Video Card and compatible super VGA colour video monitor (1024x768 capable) in order to process better quality pictures with direct video writing mode. The use of a Video Card Driver for Graphoria driver software is necessary [11]. In this case a 1024x768 resolution with 256 colours is available. The driver provides an automatic clipping, but the mouse is not supported.

Under DOS, the Microsoft Fortran compiler offers many useful graphics features. However, it does not come with a DOS Extender and will not allow access to more than 1 MB of memory regardless what DOS Extender is installed. Although one can access all the memory from MS Fortran under OS/2, one cannot use the graphics subroutines of MS Fortran available under DOS.

What the PC lacks at present is a good software tool for producing graphic user interfaces, of the type which is available for workstations (and which produce C code). Perhaps the future for the graphic user interface lies with C or C++; hence the suggestion made above concerning the linking of C with Fortran.

One possible answer to the above dilemma may be the public domain, device portable Very Ordinary Graphics Learning Environment (VOGLE) graphics library (Department of Engineering Computer Resources, University of Melbourne, Australia) which is based on the Silicon Graphics Iris GL. VOGLE comes with sufficientdocumentation to get it installed and the source code to a variety of device drivers as well as the C and Fortran interfaces. It can be used to move engineering type software between IBM PC-s and SUN workstations. VOGLE Version 1.2.2 contains a library of C routines for doing line drawings and polygon fills in 2D and 3D. It handles circles, curves, arcs, patches, polygons, and software text in a device independent fashion. Simple hidden line removal is also available via polygon backfacing. Access to hardware text and double buffering of drawings depends on the driver.

XI. CONCLUSIONS

The available Fortran compilers are capable of compiling huge programs and with the 80386 processor execution speed is acceptable. Benchmarks conducted by the Austrian group show that a 33 MHz 386 PC with 8 MB of memory is a good tool for the finite element analysis of electrical engineering problems without using virtual memory. The configuration mentioned above could reach the performance of a VAXstation 3200. To solve a relatively large 2D magnetostatic problem needs only a few minutes. A 33 MHz 486 PC is approximately three times faster, so that 3D problems can also be analyzed but preferably with 32 MB of memory. Therefore, PC performance, in general, is more than acceptable for electromagnetic field computation.

Graphics is no more difficult to use than on a workstation (e.g. SUN, IBM 6000) provided that a good set of interface routines are available at the outset so one does not spend all his time figuring out how to make things work. In general, PC-s appear to be cost-effective for both software development and use.

ACKNOWLEDGEMENTS

This survey was supported in part by a grant from Region Rhone-Alpes, France, and the Natural Sciences and Engineering Research Council, Ottawa, Canada. Review and discussion of the manuscript by Dr. G. Bendzsak is gratefully acknowledged.

LIST OF REGISTERED TRADEMARKS

REFERENCES

[1] Microsoft FORTRAN Getting Started, Ver. 5.0 for MS OS/2 and MS-DOS Operating Systems, Microsoft Corp. 1989.
[2] Microsoft FORTRAN Quick Reference Guide, Microsoft Corp. 16011 NE 36th Way, Box 97017, Redmond, WA, USA 98073-9717.
[3] Microsoft FORTRAN Reference, Ver. 5.0 for MS OS/2 and MS-DOS Operating Systems, Microsoft Corp. 1989.
[4] Microsoft FORTRAN Advanced Topics, Ver. 5.0 for MS OS/2 and MS-DOS Operating Systems, Microsoft Corp. 1989.
[5] Microsoft Editor User's Guide, for MS OS/2 and MS-DOS Operating Systems, Microsoft Corp. 1989.
[6] Microsoft CodeView and Utilities User's Guide, Ver. 2.3 for MS OS/2 and MS-DOS Operating Systems, Microsoft Corp. 1989.
[7] Lahey F77L-EM/32 FORTRAN Programmer's Reference, Rev. C, Jan. 1992, Lahey Computer Systems, Inc. 865 Tahoe Blvd, P.O.Box 6091, Incline Village, NV, USA 89450-6091.
[8] Lahey/Phar Lap DOS-Extender and Tools Reference, Rev. A, Jan. 1992, Lahey Computer Systems, Inc., 865 Tahoe Blvd, P.O.Box 6091, Incline Village, NV, USA 89450-6091.
[9] FTN77/486 Reference Manual, Rev. D, Vol. 1, Compiler System Reference, Jan. 1991, University of Salford, England. (from Salford Software Marketing, Ltd. Venables Bldg, 5 Cockroft Rd, Salford M5 4NT, England)
[10] Graphoria Library Reference, Rev. D, Apr. 1992, Lahey Computer Systems, Inc. 865 Tahoe Blvd, PO Box 6091, Incline Village, NV USA 89450-6091.
[11] Video Card Driver for Graphoria Trident Version 2.00, User's Guide, NORCOM, 1991.

ERRATA

Peter Excell apologises for some errors which crept into his ACES perspective article 'Whatever Happened to Unified Field Theory?'. The title of Einstein's first paper on relativity was of course 'On the Electrodynamics of Moving Bodies' and not 'On the Motion of Charged Bodies', although the sense is essentially the same (this resulted from an attempt to remember the German version without looking it up!). On the line above, the 'effective field' should read 'effective electric field' and two lines below this the reference to 'Maxwell's equation' should of course be in the plural.

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- Code input/output issues
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- Partial List: Applications: *antennas*, *static fields*, *shielding*, *EMP,EMI/EMC*, *charge transport*, *microwave components*, *fiberoptics*, *communications systems*, *particle accelerators*, *wave propagation*, *eddy currents*, *networks*, *radar cross section*, *bioelectromagnetics*, *power transmission*, *dielectric & magnetic materials*, *MMIC technology*, *remote sensing & geophysics*, *plasmas*, *generators and motors*, *non-destructive evaluation*, *inverse scattering.*

- Partial List: Techniques: *frequency-domain & time-domain techniques*, *integral equation & differential equation techniques*, *finite differences and finite element techniques*, *diffraction theories*, *modal expansions*, *hybrid methods*, *physical optics*, *perturbation methods*, *moment methods*

TIMETABLE

November 17, 1992	Authors notified of acceptance
January 15, 1993	Submission deadline for camera-ready copy, not more than (8) eight pages including all figures. For both summary and final paper, please supply the following data for the principal author -- name, address, E-mail address, FAX, and telephone numbers for both work and home.

Registration fee per person for the Symposium for members is $195, if paid by March 8, 1993. After March 8, fee will be $210. For Non-Members, fee will be $220, if paid by March 8. After March 8, fee will be $235.

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Short courses will be offered in conjunction with the Symposium, covering numerical techniques, computational methods, surveys of EM analysis and code usage instruction. Short courses will be conducted principally on Monday, March 22, Tuesday, March 23, and Friday, March 26. Please see page 51 of this newsletter for fees.

EXHIBITS

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

SHORT COURSES AT THE 9TH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS

The Applied Computational Electromagnetics Society (ACES) is pleased to announce eight short courses to be offered with its annual meeting of March 22-26, 1993. Times of the individual short courses are noted. Registration begins at 7:30 AM on Monday, March 22, 1993. ACES has the right to cancel a course at any time with full refund. For further information contact Richard W. Adler (408)646-2352, (408)649-0300 FAX, E-mail: 5541304@mcimail.com

COURSE INFORMATION

FULL-DAY COURSE (Monday, March 22, 8:30-11:30, 1:00-4:30PM)

"Solving Practical Problems with GEMACS" by Buddy Coffey, Advanced Electromagnetics

The GEMACS (General Electromagnetic Model for the Analysis of Complex Systems), computer program includes physics and mathematics features for method of moments (MoM), finite differences (FD), uniform theory of diffraction (UTD/GTD), as well as self- consistent hybrids of these methods. Coupled with its auxiliary graphics support (GAUGE and/or WINGAUGE) and analysis/database front end (Electromagnetic's Modeler's Workbench), the GEMACS package offers capabilities not found in other codes. Participants will learn how to formulate and solve practical EM problems with GEMACS and will include some usage of GAUGE and the EM Modeler's Workbench. Emphasis will be on multi-region problems (cavities, penetrations, etc.) and new features just released with GEMACS version 5.2: antenna pattern database, analytical source types, pattern sources, aperture-patch commands and physics. Participants should have basic background in EM numerical modeling with NEC, BSC, GEMACS or similar multipurpose software. Participants may contact the instructor in advance with problem types of particular interest.

FULL-DAY COURSE (Monday, March 22, 8:30-11:30, 1:00-4:30PM)

"EM Modeling Using the TSAR FDTD Code Suite" by Dr. K.S. Kunz, Pennsylvania State University and S.T. Pennock, Lawrence Livermore National Laboratory

This course will provide an introduction to the use of TSAR for solving practical EM problems. Fundamentals of the FDTD method will be discussed, including resource requirements and allocation, and the art of FDTD modeling will be addressed. The process of solving realistic problems will then be covered including: building a solid model; creating an FD mesh; compiling TSAR; setting up an input file; and post-processing code results. Demonstrations will include use of the graphical user interfaces as well as videotaped examples of coupling and scattering from canonical scatterers, waveguides and commercial aircraft.

MORNING HALF-DAY COURSE (Monday, March 22, 8:30-11:30AM)

"The Generalized Multipole Technique (GMT) and the Multiple Multipole Program (MMP): Theory and Practical Use in Computational Electromagnetics" by Dr. Pascal Leuchtmann, Siwss Federal Institute of Technology

This short course gives a brief overview on the the theoretical background of GMT in comparison with other techniques such as MoM, Finite Difference/Finite Elements, GTD, etc. In the main part the various MMP features and their specific practical applications are explained. The goal of the course is to provide a good knowledge of what kind of problems may be solved by the MMP, and how this is done. No specific experience in GMT is required, except for basics in electromagnetics.

AFTERNOON HALF-DAY COURSE (Monday, March 22, 1:00-4:30PM)

"CEM Modeling Options and Tradeoffs" by E.K. Miller, Los Alamos National Laboratory

The growing variety of computational electromagnetic (CEM) codes that is becoming available makes choosing a specific model for a given application increasingly confusing for the electromagneticist who is concerned with solving problems but not with becoming a software expert. This short course will compare the generic approaches on which all CEM models are based in terms of their analytical formulation, numerical implementation, and computational requirements. The relative advantages and limitations of the various model types will be summarized to identify the best modeling approach to a given problem. The goal will be to provide a basis for making more informed choices when making modeling decisions for practical applications.

AFTERNOON HALF-DAY COURSE (Tuesday, March 23, 12:30-4:00PM)

"Starting Your Own Small Business" by Buddy Coffey, Advanced Electromagnetics

There's a little bit of entrepreneur in each of us. Ever wonder what it would take to branch out on your own? This half-day course will introduce you to the ins and outs of owning your own small EM consulting/software business. We'll cover such topics as financing, marketing, and advertising, dealing with the Government alphabet soup, intellectual property rights, day-to-day business activities, rules and regulations, taxes, employees, product development, etc. To focus on a particular scenario, we'll examine EM/numerical software development, marketing, and sales as a case study. We'll try to give you a feel for just what are the issues and concerns in bringing a software product to market. The instructor is the founder and owner of Advanced Electromagnetics, a three-person EM consulting and software firm. AE has been in business since 1985, and much of the course content is gleaned from "lessons learned" over the past eight years. The software case study will be a discussion of how AE took a mainframe computer program (GEMACS) and turned it into a successful and lucrative commercial product.

FULL-DAY COURSE (Friday, March 26, 8:30-11:30, 1:-00-4:30PM)

"Wire Antenna Modeling: 20 Years of Successes, Failures and Lessons Learned, Modeling Guidelines and Some Useful Utility Programs" by R.W. Adler, Naval Postgraduate School, J. Breakall, Pennsylvania State University, and G.J. Burke, Lawrence Livermore National Laboratory.

The three instructors, together, have accumulated over 61 years of hands-on experience in developing and using versions of NEC and MININEC to solve thin-wire radiating systems. Course topics include a brief overview of thin-wire numerical modeling, features and comparisons of the various NEC and MININEC code families, limitations to and pitfalls when modeling (i.e., antennas near-ground and loops), "tricks of the trade", broadcast antenna applications, solution checks, buried wire modeling, proper use of networks and transmission lines, and the use of convenient utility codes. Students will receive a diskette containing a collection of useful support programs. In addition, students will be given an opportunity to present their wire antenna modeling problems to the instructors for guidance in laying out a NEC/MININEC modeling approach.

FULL-DAY COURSE (Friday, March 26, 8:30-11:30, 1:00-4:30PM)

"TLM Techniques for Electromagnetic Wave Modeling" by Wolfgang J.R. Hoefer, Professor, University of Victoria

This one-day short course consists of two parts. The first part is an introduction to the various time domain modeling (TLM) techniques and algorithms, including the modeling of nondispersive linear media and boundaries, John Matrix techniques, passive and active nonlinear devices and basic signal processing. The second part focuses on recently developed enhancements of the method, such as corner and edge nodes, dispersive media and wideband absorbing boundaries, and numerical synthesis by time reversal of the TLM process. Elements of parallel processing of the TLM code on SIMD-type machines will also be described. These features will be demonstrated on a computer, and a number of representative guided and radiated wave problems will be solved during the course. The course will be suitable both for participants who want to gain an overview of TLM capabilities, and for researchers familiar with basic TLM developments in the fields.

FULL-DAY COURSE (Friday, March 26, 8:30-11:30, 1:00-4:30PM)

"Reflector Antenna Code Modeling" by Dr. Roger C. Rudduck and Teh Hong Lee, The Ohio State University Electroscience Laboratory

The theory and capabilities for an enhanced version of the NEC Reflector Antenna Code will be presented. The basic approach is similar to the original NEC Reflector Antenna Code which uses aperture integration for the main beam and near sidelobes, while GTD (UTD) is used for the far sidelobes. However, a more efficient GTD approach is now used to model the general reflector rim shape. More recent capabilities including modeling of subreflectors and reflector surface distortions. Improved modeling will be described for conical horn feeds and obstacles in the reflector aperture.

SHORT COURSE FEES: / DISCOUNTS FOR EARLY PAYMENT		
PAYMENT DATE	FULL-DAY COURSES	HALF-DAY COURSES
By March 8, 1993	$130	$ 80
After March 8, but by March 21, 1993	$140	$ 90
After March 21, 1993	$150	$100

TABLE II. NEC2 RUN TIMES

Single Dble Prec.	NEC Input #Seg	Weitek	Minutes Used to Normalize	NORMALIZED RUN TIMES Microway Compiler v.386 PharL	v.386 Tools	v.486 PharL	v.486 Tools	Lahey Compiler
S	101	ON.	26.48 min	1.02	1.02	....	1.06	1.37
S	101	OFF	26.48 min	1.20	1.06	1.32	1.17	1.00
S	2112	ON	36.73 min	1.00	1.04	....	1.07	1.31
S	2112	OFF	36.73 min	1.16	1.16	1.38	1.15	1.20
D	101	ON.	34.25 min	1.13	1.22	....	1.24	....
D	101	OFF	34.25 min	1.19	1.00	1.30	1.11	....
D	2112	ON.	47.65 min	1.28	1.38	....	1.37	....
D	2112	OFF	47.65 min	1.24	1.19	1.47	1.22	1.00

Since the Lahey runs faster for some cases and the Microway for others, its a toss-up which is better for NEC. In my opinion Lahey is somewhat easier to use with better error messages and slightly better documentation. Lahey also compiles faster, but crashed on one of the NEC cases.

Some general conclusions can be drawn from Table II which are valid for most but not every case. The $900 Weitek did not help the Lahey compiler running on a 486. Lahey says this is because the 486 comes with a built-in 487 math coprocessor which is faster (for Lahey) than the Weitek, but if I had a 386 machine then the Weitek would help. The Weitek only helps the Microway compiler in single precision. The Microway Tools is faster than the Microway PharLap without a Weitek, but the reverse is true with a Weitek. Weitek Corporation says they have no plans to manufacture coprocessors for 486 computers running at 50 MHz or faster, now or in the future, because they cannot improve much on the speed of the built-in 487 coprocessors at those clock speeds.

The Microway v.386 compiler runs faster than the Microway v.486 compiler, even though it was running on a 486 machine! Microway technical help did not sound terribly surprised to hear this for version 3.1, and said that when their more recent compilers are improved so they can be used with NEC then the 486 versions should outperform the 386 versions.

Not all cases would run as shown by the ". . . . " entries. The Lahey compiler does not support the Weitek for double precision complex arithmetic. Lahey was also unable to run one Weitek off case giving an "invalid number, 0/0, or integer overflow" error message. This was a recurring problem for large double precision NEC runs using Lahey. The Microway v.486 using PharLap crashed for all "Weitek On" runs giving a "memory protection fault error" which may be a bug in my motherboard or Weitek chip since I have had occasional other problems with my Weitek.

In addition to working in DOS, both Lahey and Microway claim to run in a DOS window of OS/2 and Windows 3.x. The big advantage of this is that NEC will then run in the background while you can still use your computer to do something else. I have verified this using NEC2 for Lahey but have not tried it for Microway. The speed is halved when doing this in Windows 3.x, but not OS/2 since OS/2 (and Windows NT) are true multitasking operating systems.

EDITORS NEEDED

The ***ACES Journal*** needs reviewers for papers in the following "non-mainstream" areas:

> **computational electromagnetics input/output**: innovations in input (e.g., input geometry standardizaion, automatic mesh generation), innovations in output (e.g., tabular, graphical, statistical, or signal-processed), input/output database management, output interpretation, other input/output issues
>
> **computer hardware issues**: the analysis of hardware capabilities and limitations in meeting various types of electromagnetics computational requirements
>
> **artificial intelligence / expert systems** (in relation to computational electromagnetics)
>
> **education-related issues in computational electromagnetics**

In addition to reviewing papers, the reviewers will assist in formulating standards of publication for papers in these areas. The objective is to attract and publish "non-mainstream" computational electromagnetics papers which are appropriate for a refereed journal.

Reviewers will be considered for appointments to the Editorial Board of the ***ACES Journal.*** If you are interested, please contact:

David E. Stein
Editor-in-Chief
P.O. Box 169
Linthicum Heights, MD 21090 USA
Phone (703) 524-2117

IDEAS NEEDED

We need to find innovative ways to fund tri-annual publication of the ***ACES Journal***, so that can publish two regular issues and one special issue each year. As explained in a recent ACES Editorial Board committee report (***ACES Newsletter***, Vol. 7, No. 2, March 1992), the objective is to maintain our special issue program simultaneously with "rapid turnaround" (rapid review and publication of acceptable papers) for our regular issue contributors. Under present limitations of two issues / year, this is not always readily achievable - - although fortunately, no ***ACES Journal*** author has yet been adversely impacted.

In attempting to obtain the necessary financial resources, we must maintain membership affordability for members of all nationalities. (In some nations, the salary scale differ considerably from those in the United States. Furthermore, the postal surcharges for non-USA members of ACES are often substantial). For this reason, an increase in membership can be counterproductive. Alternative suggestions are needed. Please share your ideas with:

David E. Stein
Editor-in-Chief
P.O. Box 169
Linthicum Heights, MD 21090, USA.
Phone (703) 524-2117

CALL FOR PAPERS

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY
ANNOUNCES A SPECIAL ISSUE OF THE ACES JOURNAL ON:

ADVANCES IN THE NUMERICAL COMPUTATION OF LOW FREQUENCY ELECTROMAGNETIC FIELDS

The Applied Computational Electromagnetics Society is pleased to announce the publication of a 1993 special issue in the area of static and low frequency numerical electromagnetic field computation. This special issue has three goals: (1) to keep the high frequency community informed of advances made in the numerical solution of low frequency and static field problems in the hope that this will promote cross fertilization of ideas between the two groups; (2) show concrete examples where methods used in high frequency areas have been adapted successfully to low frequency field problems and vice versa; and (3) to focus attention on the need for educational tools for the computation of low frequency electromagnetic fields. Papers of archival value addressing these goals and dealing with the following suggested topics are welcome for submission.

SUGGESTED TOPICS

- Electrostatic Fields and Applications
- Magnetostatic Fields and Applications
- Eddy Current, Skin Effect and Proximity Problems
- Electric Machines and Other Devices
- Transformers and Inductors
- Finite Difference and Related Methods
- Finite Element and Related Methods
- Integral Equation Methods
- Gaseous Discharges and Corona
- Other Static and Low Frequency Phenomena
- Electromagnetic Brakes, Bearings, Levitation
- Electromagnetic Launchers
- Power Transmission
- Nonlinear Materials
- Unbounded Problems
- Coupled Problems
- Multigrid Methods
- Time Domain Methods
- Code Validation
- CAD
- Efficient Equation Solvers
- NDE and NDT
- Automatic Mesh Generation
- Accelerator Magnets

DEADLINE FOR PAPERS IS MAY 31, 1993

Send papers and inquiries to:

A. Konrad and J.D. Lavers
Special Guest Editors
Department of Electrical Engineering
University of Toronto
10 King's College Road
Toronto, Ontario
CANADA M5S 1A4

Tel: (416)978-1808
Tel: (416)978-6842
FAX: (416)978-7423
Email:konrad@power.ele.toronto.edu
lavers@power.ele.toronto.edu

COMPUMAG - Miami

The 9th COMPUMAG Conference on the Computation of Electromagnetic Fields will be held in Miami, FL from October 31 to November 4, 1993. The aim of the Conference is to discuss recent developments and practical applications in the numerical computation of electromagnetic fields for engineers and physicists engaged in the design and analysis of electromagnetic devices. Reflecting the new trends and rapid progress in the field, authors worldwide are invited to submit original and not previously published contributions in various areas. The Conference will feature oral and poster presentations. Panel discussions and invited speakers will focus attention on future trends in areas of interest to the Conference.

Suggested topics for papers include:

- Magnetostatic and electrostatic field calculations for both linear and non-linear problems
- Time-dependent fields, including transient and steady state behavior of electromagnetic de-devices, eddy currents, and skin effect
- Wave propagation problems including microwaves and antennas
- Optimization using deterministic and stochastic methods, artificial intelligence applications
- Modeling of material properties covering superconducting, composite, and microwave absorbing materials and numerical treatment of anisotrophy, hysteresis, permanent magnets
- Moving boundary problems, as well as electromagnetic fields coupled to mechanical, electronic, thermal, and/or flow systems
- Numerical methods and techniques, including mesh generation, adaptive meshing, error estimation, eigenvalue problems, solution of algebraic systems of equations, parallel and vector computations, and hybrid methods
- Software methodology and interactive computer aided design for electromagnetics including visualization, knowledge based systems, AI-techniques, and massively parallel algorithms
- Original applications of computer programs in the areas of electric machines and drives, high magnetic field devices, superconducting magnets, waveguides, microwave resonators, biomedical applications, inductive heating, and calculation of local and integral parameters

Submission of papers

Papers should be submitted to the Conference Secretariat by **February 12, 1993**. They should include an abstract, not exceeding 100 words and should not exceed two double column pages in overall length, including figures, tables, and references. In the paper, there should be sufficient details to clearly explain the author's idea, method, or formulation. The paper should contain results showing that the work presented has already matured to the level of publication. Therefore, authors should present enough pertinent information in the paper to allow reviewers to evaluate its merit correctly. The Conference Record will include all accepted papers and will be made available to all participants at the beginning of the Conference.

Extended versions of papers are due by **September 30, 1993.** They will undergo a new peer review in accordance with the rules of the *IEEE Transactions on Magnetics*, in which the accepted extended papers will be published.

Following the completion of the review process, information will be sent to authors on the acceptance and form of the presentation of their papers by May 1993. All extended papers received and presented at the Conference will be submitted to new peer review and the accepted papers will be published in a special issue of *IEEE Transactions on Magnetics*.

Conference Language

The official language of the Conference will be English. Paper review will be based on the technical merit of the work submitted. Papers suffering from excessive grammar and spelling mistakes and poor English, however, may be returned to the authors because of the difficulty in evaluating them.

Conference Program

The Conference Program will consist of four full days of oral, poster, and panel sessions. Invited speakers, in both paper and panel sessions, will be scheduled each day. A detailed preliminary program will be sent to all registrants before the Conference.

Companies and research organizations will have technical and commercial exhibitions during the Conference.

Post Conference Activities

The final ACES/TEAM Workshop of the IVth Round will follow COMPUMAG-Miami on November 5-6, 1993.

Additional Information

For detailed information please contact:

COMPUMAG - Secretariat
Department of Electrical & Computer Engineering
Florida International University
Miami, FL 33199, U.S.A.
Phone (305) 348-3711 (305) 348-3040
Fax (305) 348-3711 (305) 348-3707
E-Mail: ulerf@servax.fiu.edu

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

9TH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS

March 22 - 26, 1993
Naval Postgraduate School
Monterey, CA

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Registration

Please check applicable boxes.

		Registration Fees: By 3/8	After 3/8
☐ ACES MEMBER	Includes Sessions, Exhibits, Wine & Cheese Buffet, and Proceedings	☐ $195	☐ $210
☐ NON-MEMBER	Includes Sessions, Exhibits, Wine & Cheese Buffet, and Proceedings	☐ $220	☐ $235
☐ STUDENT	Includes Sessions, Exhibits, Wine & Cheese Buffet, and Proceedings	☐ $135	☐ $135
☐ BANQUET	March 24, 1993	☐ $ 23	

Short Courses

COURSE FEES: FULL-DAY: $130 if rcvd **by** 3/8; $140 **after** 3/8 **to** 3/21; $150 **after** 3/21/93.
HALF-DAY FEE: $80 if rcvd **by** 3/8; $90 **after** 3/8 **to** 3/21; $100 **after** 3/21/93.

☐	"SOLVING PRACTICAL PROBLEMS WITH GEMACS" by Buddy Coffey FULL-DAY Monday March 22.	☐ $130	☐$140	☐ $150
☐	"EM MODELING USING THE TSAR FDTD CODE SUITE" by K Kunz & S Pennock, FULL-DAY Monday March 22.	☐ $130	☐$140	☐ $150
☐	"THE GENERALIZED MULTIPOLE TECHNIQUE (GMT) AND THE MULTIPLE MULTIPOLE PROGRAM (MMP): THEORY AND PRACTICAL USE IN COMPUTATIONAL ELECTROMAGNETICS", by Pascal Leuchtmann MORNING HALF-DAY Monday March 22.	☐ $ 80	☐$ 90	☐ $100
☐	"CEM MODELING OPTIONS & TRADEOFFS" by E K Miller AFTERNOON HALF-DAY Monday March 22.	☐ $ 80	☐$ 90	☐ $100
☐	"STARTING YOUR OWN BUSINESS", by Buddy Coffey AFTERNOON HALF-DAY Tuesday March 23.	☐ $ 80	☐$ 90	☐ $100
☐	"WIRE ANTENNA MODELING: 20 YEARS OF SUCCESSES, FAILURES AND LESSONS LEARNED; MODELING GUIDELINES AND SOME USEFUL UTILITY PROGRAMS" by R W Adler, J K Breakall, and G J Burke FULL-DAY Friday March 26.	☐ $130	☐$140	☐ $150
☐	"TLM TECHNIQUES FOR ELECTROMAGNETIC WAVE MODELING" By W. Hoefer, FULL-DAY Tuesday March 26.	☐ $130	☐$140	☐ $150
☐	"REFLECTOR ANTENNA CODE MODELING" by R Rudduck and T H Lee FULL-DAY Friday March 26.	☐ $130	☐$140	☐ $150

SEE PAGE 51 OF THIS NEWSLETTER FOR DETAILS OF SHORT COURSES

RETURN COMPLETED FORM WITH PAYMENT BY MARCH 8, 1993 to:

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