# APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

## NEWSLETTER

Vol. 11 No. 3 November 1996

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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.

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# OFFICER'S REPORTS

## SECRETARY'S REPORT

### ACES BOARD OF DIRECTORS MEETING

The semi-annual meeting of the ACES Board of Directors was held on Saturday, 21 September 1996, by teleconference. Participants were: Harold Sabbagh (HS), Ed Miller (EKM), Todd Hubing (TH), Andy Peterson (AP), Pat Foster (PF), Jim Breakall (JB), Dick Adler (DA), Robert Bevensee (RB), Adalbert Konrad (AK), and Eric Michielssen (ECM). John Brauer, Duncan Baker, and Perry Wheless were unable to attend, and proxies were assigned to other board members.

Discussion Notes

The latest ACES Financial Report indicates cash assets of approximately $126k in CDs, Savings, and Checking accounts. RB reported on two major Conference Committee action items: short course guidelines and a policy on multiple paper submissions to the conference. Recommendations for short course guidelines were discussed, but no formal action was taken. Authors for ACES '97 should be aware of the page limits policy which was adopted in Monterey at ACES '96, namely

i. The recommended paper length is six (6) pages, with eight (8) pages as a maximum.

ii. Each conference registration entitles the registrant to no more than sixteen (16) pages, total, in the Conference Proceedings.

iii. The mandatory excess page charge for pages in excess of (1) eight (8) pages for a single paper, or (b) sixteen (16) total pages is $15/page. Authors with any questions about free Conference Proceedings page allocations for ACES '97 should contact ECM. The proposed Technical Chairman for 1998 is Jiamning Jin. Keith Whites will serve as Assistant Chairman in 1998, and has expressed interest in the Technical Chair for 1999. ACES members interested in conference service are invited to make their interest known to any of the ACES Directors.

JB presented details of a proposed ACES Workshop/Short Course for 21-24 September 1997, to be held at Penn State University. JB will prepare a memorandum of agreement for consideration of the full BoD before a formal vote on this matter is taken.

AP presented a proposal for retired ACES members to enjoy the same membership and conference fees as full-time students.

Atef Elsherbeni was recently appointed Chair of the Software Exchange Committee. Ideas for Software Exchange activities should be directed to Atef. The Software Sourcebook being compiled by EKM may be available in first draft form by March (ACES '97), but responses from companies has been slow.

PF reported a one-day meeting of the ACES UK Chapter on Time Domain Calculations. A two-day NEC Short Course will be offered next April.

The ACES Web site was discussed by TH, particularly links to the ACES site from sites of other agencies and companies. For now, it was agreed to make links available to ACES Institutional Members. Interested parties should contact TH.

Summary of Motions Approved

MOTION 1. Approve a Student Prize Paper Contest for ACES '97 with three judges from the BoD to select a winner. The prize is to be (1) a free pass to the next Annual Review, (2) a free Short Course registration at ACES '97, and (3) $200 cash.

MOTION 2. Require essentially all viewgraphs and a course outline to be made available to students in ACES short courses.

MOTION 3. Reduce the payment to short course instructors by 15% if the outline and essentially all viewgraphs are not available at least a week before the short course, and by 25% if the same materials are not available at the short course.

MOTION 4. Approve JB and the Conference Committee to obtain full information on the details of the workshops and short courses proposed for September 1997 at Penn State University.

MOTION 5. Extend reduced ACES membership/dues AND conference registration fees currently in effect for "students" to those who state they are retired. The current fee category labeled "student" will henceforth be labeled "student/retired." In all cases, a signed statement of the member/attendee is deemed sufficient proof of status.

Secretary's Note: Subsequently, by poll of the BoD, the provision has been added that Annual Review "student/retired" registration fees do NOT include a copy of the conference Proceedings.

MOTION 6. Financially disadvantaged members may also be granted the student/retired rate IF they request it AND if they have previously paid regular membership dues for at least two years. A signed statement of the member/attendee is deemed sufficient proof of status.

MOTION 7. Links to the ACES Web site shall be limited to ACES Institutional Members only.

Submitted by
W. Perry Wheless, Jr.
ACES Secretary

## PERMANENT STANDING COMMITTEES OF ACES INC.

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# COMMITTEE REPORTS

## ACES PUBLICATIONS

In the last Newsletter, we noted that ACES Journal Special Issues have been particularly effective in recent years for the dissemination of technical information on specialized topics in CEM. This Publications report continues to focus on Special Issues, because we need to have additional issues starting into the pipeline if they are going to pop out in a timely manner!

From the most recent "ACES Member Satisfaction and Feedback Survey," the following Special Issue topics were most frequently indicated to be of interest to the ACES membership at this time:

1. EM Modeling for Microelectronic Packaging.
2. Optimization and Inverse Problems in EM Products and Systems.
3. Vectorization and Parallel Computation Techniques.
4. Error Analysis and Validation.
5. Hybrid Numerical/Asymptotic Methods for Scattering.
6. Progress in Low Frequency Techniques.
7. Computer-Based Design Optimization.
8. Dense Matrix Solution Techniques.
9. Selected Papers from Regional CEM Conferences.

To this list might be added a subsequent suggestion of

10. CEM Applications in Wireless Communications Systems.

At present, three Special Issue projects are underway. Two of these involve selection of the "best" (best in the combined sense of technical merit and interest to ACES) papers from two conferences. One conference was conducted in Brazil and the other in Austria. These are high-quality papers which are not published elsewhere, and we believe they will be of significant interest and utility to ACES members. These two projects are "experimental" projects in that Special Issues of this nature are unprecedented in the history of ACES publications, and the Publications Committee has decided to defer similar agreements with other CEM conferences until the success of this approach to locating state-of-the-art material is proven in practice. There are numerous opportunities with other specialized conferences, but the ACES membership will decide, based on the results of these two demonstration projects, if we are to actively pursue this strategy on a long-term basis. The third active project is the Special Issue of David Davidson and Tom Cwik on "Computational Electromagnetics and High-Performance Computing," to appear in 1998.

Are you in a position to serve as Editor or co-Editor for one of the other topics above? Do you have a topic which should be on our list of prospects, but is not? If you feel that you do not have the hours or contacts to serve as Editor for such a project, it is still quite possible that you are acquainted with someone in the CEM community who is both willing and able to serve. Please give this matter some thought, and get in touch with me at your earliest convenience if you require further encouragement, or merely a contact point to register your ideas and suggestions.

Submitted by
W. Perry Wheless, Jr.
ACES Publications Chairman and Editor-in-Chief
e-mail wwheless@ua1vm.ua.edu

# NOMINATIONS COMMITTEE

In the coming months, ACES members will be asked to vote for three board members. For uniformity, each candidate will be asked to provide a short statement that addresses:

(1) GENERAL BACKGROUND (e.g., professional experience, degrees, employment, etc).

(2) PAST SERVICE TO ACES (e.g., service on ACES committees, or other contributions).

(3) CANDIDATES' STATEMENTS (e.g., short statement of the candidates views of major issues relevant to ACES). Candidates' statements will be no more than 500 words, unless otherwise directed by the board.

(4) OTHER UNIQUE QUALIFICATIONS (An additional but optional statement).

It is hoped that these areas will provide data on each candidate that might otherwise be obscured in a general, unstructured statement. When the time comes, please take a few minutes to study the candidates' statements and vote.

## Directors-at-Large

| | | | | | |
|---|---|---|---|---|---|
| Duncan C. Baker | 1997 | Pat Foster | 1998 | John Brauer | 1999 |
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# CEM NEWS FROM EUROPE

Coordinated by Pat Foster, MAAS, UK[1]

This issue's column is concerned with the Conference on "Computation in Electromagnetics" (CEM-96) held in Bath, UK, in April 1996, which was a very successful event. There were 130 attendees and 80 papers were presented. Three invited lectures were given by eminent speakers.

Professor Raj Mittra of Illinois talked about methods of dealing with scattering from large bodies when the size becomes unsuitable for MoM techniques. The methods developed by him apply an extrapolation of the coefficients of basis functions calculated at a manageable frequency, to frequencies which are much higher. This was discussed again at a Panel Meeting, chaired by Colin Sillence of British Aerospace's Sowerby Research Centre on Hybrid Methods. There was a lively discussion on the topic, which means different things to different people! To some, it means how do you get the RCS of a complex body, to others it means how do you get the radiation pattern of an antenna on an aircraft at high frequencies, when the local structure is in the reactive near field of the antenna, to yet others, it means how do you get resonance modes of a structure when modelling the fine details is out of the question.

The second invited lecture was by Dr. O'Neill, of Newcastle, who talked about "Semiconductor Technology Computer Aided Design". Few papers on this topic are ever seen at CEM Conferences and yet the methods and aims are very much the same, as well as the difficulties. Model the device in detail and where is a big enough computer? Simplify it and are the results poor because of simplification, or because the method is fundamentally unsound?

Professor V.M. Babich of St. Petersburg was, by happenstance, visiting Bath University and agreed to address the Conference on work in diffraction theory at St. Petersburg. Much of this work is concerned with diffraction from cones of arbitrary cross-section.

There were a number of special sessions on such topics as "Novel Computing", "Software Integration", "Processing" and "Sensors", as well as sessions on standard topics like "Boundary Elements", "Integral Equations" and so on. The session on "Software Integration" was on what might be termed the use of several techniques all at once. The Research and Engineering Framework (REF) which is known to ACE's members through papers at the ACES Symposium, was presented by Dr. Hantman. Tony Brown talked about the design of reflector antennas at his Company, going from RF design, through standard and mechanical computation and back to the output of the final product. An enthralling paper was given by H.A. Nott of Australia, on his visualization of antenna patterns - the only CEM paper I have ever attended which had the audience rolling in the aisles!

No conference would be complete without social events. The City of Bath invited us to take wine with them in the Roman Baths. The Banquet was held in the 18th century Pump Room above, complete with a string quartet, which went from Haydn to the Beatles. There was a poster session of 18 papers, with a buffet supper, but the highlights of the conference was undoubtedly the skittles match after the poster session. "High Frequency" team, captained by yours truly, versus "Low Frequency" team, captained by Chris Emson, a well-known Compumag supporter. I do not remember who won. The beer was very good!

---

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# MODELER'S NOTES

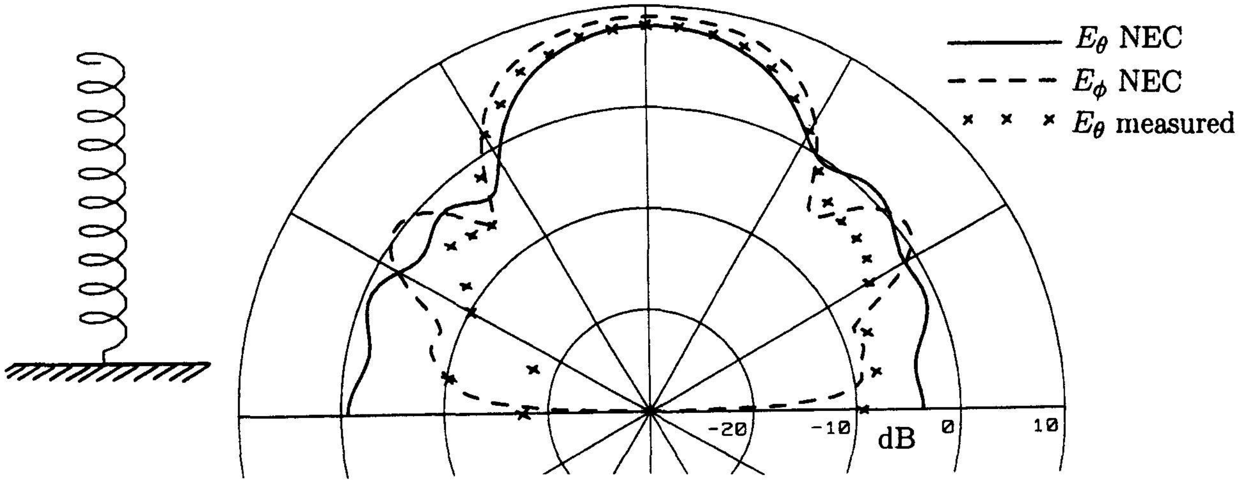
Gerald J. Burke

For this issue of the Newsletter we have a contribution from B. Neta and J. B. Knorr on their experience running NEC–4 on the Cray computers at the Naval Postgraduate School. While there are a number of Crays at LLNL, we do not use them for NEC work, since they are too expensive for low-budget projects. Hence when people request NEC for a Cray we can only supply the generic version and wish them luck. Professors Neta and Knorr point out some minor changes needed to run NEC–4 on a Cray and also provide information on running times. Table 1, which includes only the time for processing the model geometry data, shows the relatively large time, proportional to $N^2$, spent checking for geometry errors such as incorrect segment intersections. This checking can be turned off with -1 as the second parameter on the GE command, which apparently is what has been done for the third column of Table 2. They report a substantial reduction in time to factor the matrix by using a parallel routine for the Cray, and offer to provide this and other modified routines to people requesting them. Their article follows this introduction, after we cover a couple of other NEC subjects.

One issue that has come up several times lately is an error when running more than 10000 wire segments in NEC–2, 3 or 4. Such large models may give an error message "CONNECT: SEGMENT CONNECTION ERROR FOR SEGMENT _." The reason is that the connection of a segment end to a patch is indicated in the code by a connection number (ICON1 or ICON2) of 10000 plus the number of the patch. Thus a connection number of 10005 means that the segment end connects to patch number 5. Obviously if the number of segments exceeds 10000 the code will confuse a wire connection with a patch connection. This value of 10000 is embedded in several places in the code, since when NEC–2, 3 and even 4 were released we did not expect people to run more than 10000 segments. The rapidly increasing speed and capacity of computers has change that.

The 10000 segment limit can be changed by editing the code to increase the constants to some value larger than the maximum number of segments that you expect ever to use. In NEC–2 there are 23 values of 10000 that must be changed and 2 values of 10001 that are changed to the new value plus one. There are also 2 values of 10000 in subroutine INTRP that are not changed and a decimal 10000. in subroutine PATCH that does not need to be changed. NEC–3 is the same as NEC–2 but without the two values in subroutine INTRP. In NEC–4 there are 20 values of 10000 and 2 values of 10001 that must be changed. There are 2 values of 10000 in the LINPAK subroutine CQRSL and the 10000. in PATCH that are not changed. NEC–4 also uses the value 20000 to indicate connection of a segment to a ground plane, so if the number of segments is expected to get this high the value should be increased. There are 6 values of 20000 in statements and 4 in comment lines in NEC–4. Uno Lidval at Communicator CEC in Sweden has suggested using the parameter value MAXSEG from the INCLUDE file in place of the fixed value 10000. The values to replace 20000 could be computed from MAXSEG by adding a "safe" number to allow for patch connections. Another option would be to use a new parameter, since if you use MAXSEG then a NGF file for a model with wires connecting to patches may not work with a code compiled with a different value of MAXSEG than when the NGF file was written. Using an even number like 10000 makes it easy to read the table of connection numbers and determine the numbers of connected patches, but it is probably not often that people read the geometry table for a large model.

A recent topic of discussion on nec-list@ee.ubc.ca has been modeling of helical antennas with NEC, and a claim was made that NEC is completely unreliable for helices due to their waveguide nature. Multi-arm helices, such as the quadrifilar, can certainly be a problem for the NEC point-matched solution, and Galerkin moment-method codes that have a continuous weighting function may be better for modeling such antennas. NEC seems to handle simple helices well though. The figure below shows the radiation pattern of an axial-mode helix modeled with NEC–4 compared with measurements by Maclean and Kouyoumjian and included in the book *Antenna Theory and Design* by Stutzman and Thiele. The helix had 10 turns with a circumference of 1$\lambda$ and pitch angle of 13°. The wire radius was chosen as 0.01$\lambda$ for the NEC model. The NEC results are in reasonably good agreement with the normalized measured pattern over the main beam, while the lower regions of the patterns differ, in part, due to the finite back plane used in the measurements and infinite plane in the NEC model. The NEC pattern was computed in the plane containing the source and helix ends, and a different side-lobe structure was found in the orthogonal plane. Initially the NEC model was made with the helix connecting to the ground plane and the first segment excited. However, this resulted in an average gain of about 1.7 when it should be 2.0 over perfectly conducting ground. The helix was then lifted by 0.1$\lambda$ and a vertical section of two segments was inserted between ground and helix with the lower segment excited. This resulted in an average gain of 2.005, and was used for the plot.



The propagation constant for a helix throughout the pass band has been found to be in very close agreement with the solution of the tape-helix determinantal equation for helix pitch angles of 2 to 10 degrees and wire radius equivalent to tape width. While this comparison cannot easily be done in the stop band, where the helix radiates in axial mode, the comparison supports the accuracy of NEC for helices. As always, it is good to check average gain and solution convergence for antennas modeled.

Thanks again to Professors Netta and Knorr for their contribution on running NEC–4 on a Cray. As usual, if anyone can contribute material on modeling, NEC or otherwise, they are encouraged to submit it to our editor Ray Perez or to Gerald J. Burke, Lawrence Livermore National Lab., P.O. Box 5504, L-156, Livermore, CA 94550, phone: 510-422-8414, FAX: 510-422-3013, e-mail: burke2@llnl.gov.

# Running NEC4 on the Cray at N.P.S.

**B. Neta**
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**J. B. Knorr**
Naval Postgraduate School
Monterey, California

September 19, 1996

NEC4 is the latest version of Numerical Electromagnetic Code developed at Lawrence Livermore National Laboratory to analyze electromagnetic responses of antennas and scaterrers. The code is based on the method of moments to solve integral equations.

In order to run the program on a Cray computer one must modify the subroutine PARSIT by replacing the two read statements by decode statements as follows:

```
      READ(BUFFER(1:LENGTH),*,ERR=9000) INTFLD(I)
```

by

```
      DECODE(LENGTH,9998,BUFFER) INTFLD(I)
9998  FORMAT(i40)
```

and the statement

```
      READ(BUFFER(1:LENGTH),*,ERR=9000) REFLD(I-MAXINT)
```

by

```
      DECODE(LENGTH,9997,BUFFER) REFLD(I-MAXINT)
9997  FORMAT(G40.0)
```

The subroutine SECOND must be replaced also since Cray has its own SECOND function. We renamed the subroutine sSECOND.

Profiling a run on a Cray shows that for a case with 6931 segments, we have:

| Subroutine | percentage |
|---|---:|
| SEGXCT (tests pair of segments for intersection) | 31.0% |
| SEGCHK (calls SEGXCT to check) | 30.8% |
| SQRT | 20.0% |
| CONECT (sets up segment connection data) | 14.8% |
| sort | 1.7% |
| all others | 1.7% |

Table 1: Total run time on Sirius (8 processor Cray) is 11.9 hours

We have concluded that we can save time by avoiding the processing of geometry. This is useful when one wants to run several cases for the same geometry configuration. To this end we modified the subroutine DATAGN.

We have added in the beginning of the program the following statements:

```
c
c  do we read geometry data from GW (and other) cards or from a file
c
      write(*,100)
100   format(' do we have geometry cards to process'/
     &       ' or all cards were processed before'/
     &       ' please answer y if geometry cards are to be processed')
       read(*,102,err=104) ny
102    format(a)
       print *,'  ny ',ny
c        if(ny.eq.'y') go to 110
c
c      the answer is NO
c      geometry cards were already processed
c      ask for geometry file name
c
       write(*,106)
106    format(' what is the geometry file name?')
       read(*,91,err=107) geom
91     format(a)
       if(geom.ne.' ') open(unit=19,file=geom,status='unknown',err=335)
       if(ny.eq.'y') go to 110
       go to 200
335    write(*,109)
109    format(' open error for geometry file')
       stop 109
104    write (*,105) ny
105    format(' read error y/n  answer was ',a1)
       stop 105
107    write(*,108) geom
108    format(' error in reading name of geometry file '/
     &        ' name was ',a)
       stop 107
110    continue
```

At the end we add the writing to the geometry file

```
      write(19,70) x
      write(19,70) y
      write(19,70) z
      write(19,70) si
      write(19,70) bi
      write(19,70) alp
      write(19,70) bet
      write(19,70) salp
      write(19,70) t2x
      write(19,70) t2y
      write(19,70) t2z
70    format(5f11.5)
      write(19,71) icon1
      write(19,71) icon2
      write(19,71) itag
      write(19,71) iconx
      write(19,71) ipsym,ld,n1,n2,n,np,m1,m2,m,mp,nwire,isct,iphd
71    format(10i5)
```

```
375   WRITE(3,72)
72    format(5x,'error writing to file 19 geom')
      STOP
c
c     read previously processed geometry file
c
200   continue
      read(19,70) x
      read(19,70) y
      read(19,70) z
      read(19,70) si
      read(19,70) bi
      read(19,70) alp
      read(19,70) bet
      read(19,70) salp
      read(19,70) t2x
      read(19,70) t2y
      read(19,70) t2z
      read(19,71) icon1
      read(19,71) icon2
      read(19,71) itag
      read(19,71) iconx
      read(19,71) ipsym,ld,n1,n2,n,np,m1,m2,m,mp,nwire,isct,iphd
      return
```

The timing on the Jedi (4 processor Cray computer) is given in table 2.

| Subroutine | Create | Use | Do Not Check |
|---|---|---|---|
| | Geometry | | |
| FACTR | 68.10% | 70.30% | 69.90% |
| CMWW | 6.08% | 6.19% | 6.14% |
| EKSCLR | 4.57% | 4.70% | 4.65% |
| EKSCSZ | 3.70% | 4.00% | 3.90% |
| EFLDSG | 3.40% | 3.40% | 3.40% |
| all others | 14.10% | 11.40% | 11.90% |
| Total Time (secs) | 13548.20 | 13074.75 | 13184.75 |
| Total Time (hours) | 3.76 | 3.63 | 3.66 |

Table 2: Timing comparison for geometry check on Jedi

We conclude that we save 473 seconds by using previous geometry file and 360 second by not checking the geometry at all. This is not much in comparison to almost 4 hours of run time.

As one can see in the previous table, the most time consuming routine is FACTR. Thus, to save computer time we decided to parallelize the LU factorization algorithm. The subroutine FACTR was replaced by a parallel algorithm on the Cray. The results are given in table 3.

| Subroutine | 3 processors | 4 processors |
|---|---|---|
| FACTR | 50.4% | 50.0% |
| CMWW | 10.5% | 10.6% |
| EKSCLR | 7.0% | 7.1% |
| EKSCSZ | 6.5% | 6.7% |
| EFLDSG | 5.5% | 5.4% |
| all others | 20.0% | 20.2% |
| Total Time (secs) | 8845.09 | 8844.86 |
| Total Time (hours) | 2.46 | 2.46 |

Table 3: Timing comparison for parallelization of LU factorization on Jedi

We save 1.2 hours (one third of the computer time) by factoring the matrix in parallel. The next time consuming part of the code is the process to fill in the matrix. In table 4, we give the time for fill-in and factor in serial and parallel versions of NEC4. Remember that the only part we parallelized is FACTR subroutine.

| Subroutine | Serial | 3 processors | 4 processors |
|---|---|---|---|
| fill-in | 3866.87 | 4112.59 | 4103.92 |
| factor | 9191.70 | 4644.98 | 4653.19 |

Table 4: CPU time in seconds on Jedi

Notice that now the factorization in parallel takes as much time as the fill-in process. Certainly the next step in parallelization is the fill-in.

Anyone interested in such a version can send a request to bneta@nps.navy.mil attaching the routines PARSIT, SECOND, DATAGN and FACTR.

# The Practical CEMist

## - Practical Topics in Communications -

**Perry Wheless, K4CWW**

Our featured article author began his two-part paper in the March 1996 issue of The ACES Newsletter. Please see pages 28-33 of Newsletter vol. 11, no. 1, for Part I of "The Twin Delta Loop Antenna: a Novel Approach to the Ultimate Multiband Antenna" by Rudy Anders, AA2HT. Because Rudy was moving, he did not have Part II completed in time for the last Newsletter, but we are pleased to have Part II for your consideration in this issue.

Several readers have inquired about the completion of this paper, and hopefully this issue will reach them in time to construct and erect a twin-delta loop array before winter weather sets in.

Since the addition of the 17m and 12m WARC bands, there are five amateur HF bands between 20 and 30 MHz. As a result, an increased number of active amateurs have been using broadband antennas, like the log-periodic (LPDA) array, in order to cover all these bands with a single antenna. However, as Rudy pointed out in Part I of his paper, the LPDA is subject to objectionable noise characteristics and, furthermore, may allow receiver front-end overload from strong out-of-band signals. The twin-delta loop antenna described here is in the major alternative category of a multiband (versus broadband) antenna and, as a result, it enjoys some distinct advantages over the LPDA and similar broadband antennas.

The electrical characteristics and performance of the twin-delta loop antenna are certainly attractive. If you choose to install one of these antennas and gain some operational experience, particularly in DX applications, we would be pleased to have you submit a report of your findings and results as a user.

Our thanks to Rudy for his development and reporting work on an antenna type which is both interesting and highly functional. Development of useful wire antennas has been a traditional strength for ACES, and contributions such as the twin-delta loop help us continue the tradition. Keep these cards and manuscripts coming!

On another topic, briefly, please note that a second "CEM Applications in Amateur Radio" session is planned for the ACES '97 conference. The first session, held at ACES '96 was successful, and I hope you will plan to attend this session in Monterey, CA, next March. In 1996, we experimented with having the session on Monday evening after a social dinner gathering, and the results were quite positive. Monday evening has the advantage of providing a relaxed environment before the more hectic schedule of the conference (Tuesday through Thursday) kicks in, and we probably will use a similar session format again for 1997, except that we conduct the session away from the Naval Postgraduate School. Plan to be in Monterey by Monday evening, and check Vol. 12 no. 1 of the Newsletter for more details about this special session. CU at ACES '97!

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# The Twin-Delta Loop Element
# In a Multiband Parasitic Beam Arrangement

## Part II

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Roswell, GA 30076

### 1. Introduction

Part I of this paper[1] introduced the single Twin-Delta Loop element as a novel all-band antenna for operation on the 20m - 10m amateur HF DX bands. Because of its true multiband behavior it seems only logical to consider the TDL element as basis for a parasitic beam arrangement.
With an almost constant horizontal beam width and gain increasing with frequency and the 100% structure efficient trapless design the TDL beam comes very close to the ideal of a directive multiband beam antenna.

### 2. Requirements and Properties of the TDL element for Parasitic Multiband Beam Application

To be a viable candidate for multiband applications a prospective parasitic element, must not only experience low impedance resonance but also ensure broadside radiation around the operation frequencies.

Open-ended (or open-circuit) elements, as the reflector or director dipole elements in YAGI-UDA array beams, are not by themselves suitable without drastic electric modifications, not even for the harmonically related classical 20/15/10m bands. Only through (lossy) traps will open-ended elements establish the required multi resonances and maintain broadside radiation.

Closed-loop (or short-circuit) elements on the other hand through the lack of capacitive open-end dispersion resonate accurately on harmonically related frequencies.
Designed as closed-loop system to maintain maximum broadside radiation on all of its bands of operation, it is this closed-loop feature that makes the TDL element a prime candidate for parasitic multiband beam applications.

In order for a TDL element to operate as a parasitic reflector a short-circuit stub is attached at the input terminal. As a rule of thumb a multiple of one half of the wavelength at the band center operating frequency is required for the total length of half the circumference of one of the delta loops of the TDL element and the overall length of the close-circuit stub plus about 4.5%.
For a standard 7.70m x 7.70m (25.25ft by 25.25ft) TDL element [1] to operate as 3-band reflector on 20/15/10m a short-circuit stub of length 12.45m/40.85ft (v=1.0) is required, where half the circumference of one of the delta loops of the standard TDL element is 9.30m/30.50ft. As will be seen from the examples given other band selections will require other stub lengths.

## 3. The 2-Element 3-Band TDL Beam for 20/15/10m Operation

The most basic 2-element TDL beam can built by simply placing 2 standard TDL elements spaced parallel to each other, where one element is fed and the other one dimensioned as parasitic reflector as given above. A 3-band set up for the classic HF DX bands 20/15/10m is shown in Fig.1. As with other 100% structure efficient multiband beam antennas [2],[3] the element spacing can be optimal only on one band and must be a compromise on the others. Computer optimization[4] for gain and front/rear ratio yields the spacing to be best at 2.50m/8.20ft for the 2-element beam on 20/15/10m. This corresponds to a relative spacing of about 0.125 on 20m, 0.167 on 15m and 0.25 on 10m. The actual spacing is not at all critical but requires the reflector stub to be readjusted for best front/rear ratio.

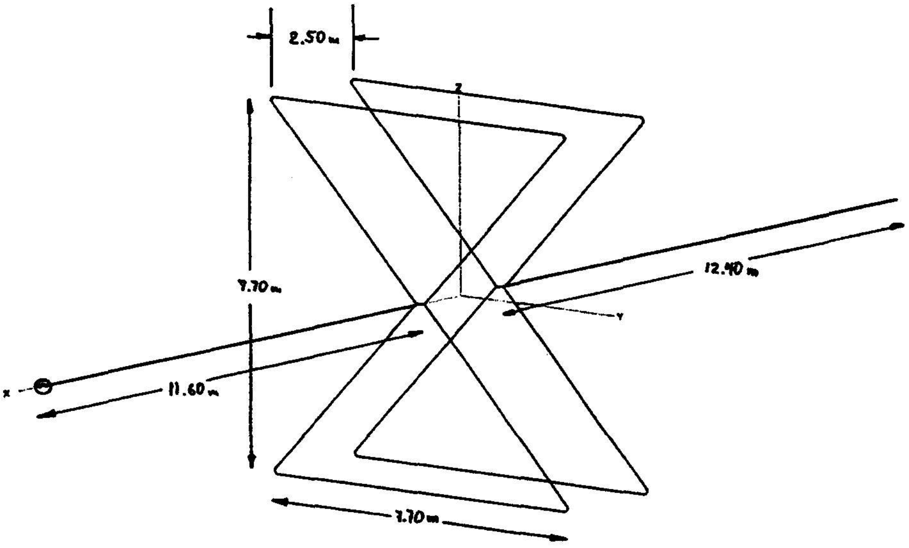

Fig. 1 Geometry of a 2 element TDL beam in a reflector-feeder arrangement for 20/15/10m

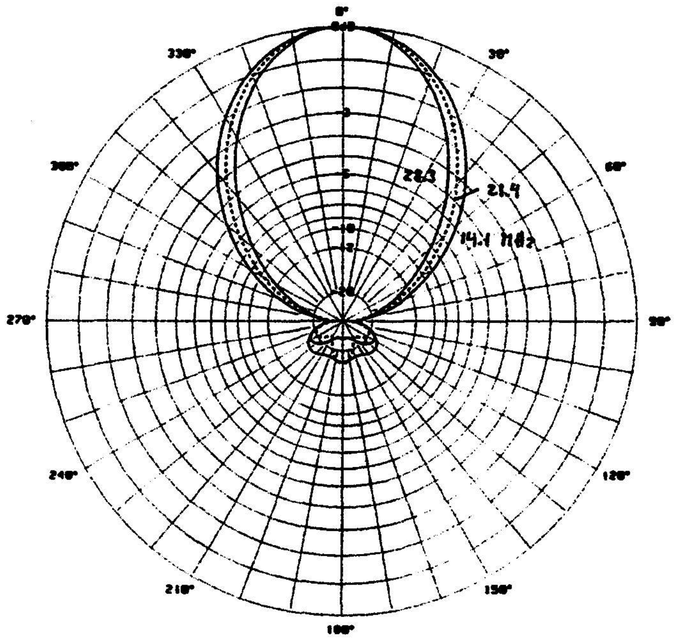

Fig. 2 Horizontal cut farfield (elevation 9°) of the 2 element 20/15/10m TDL beam in free space

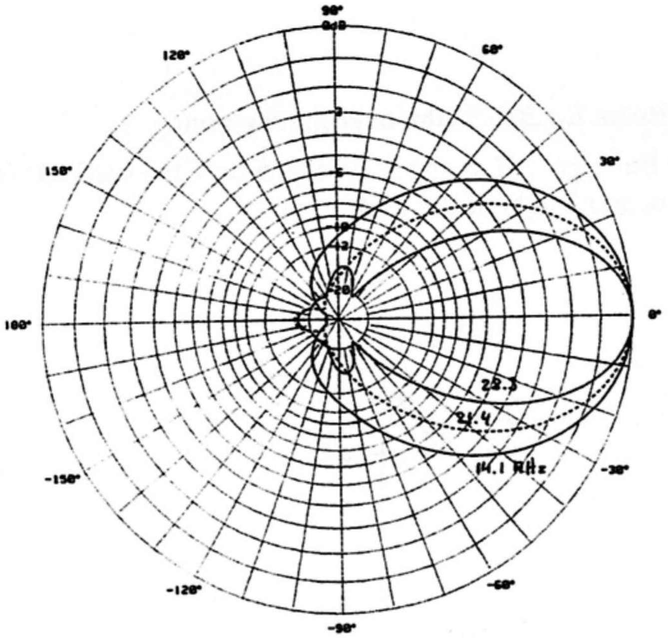

Fig. 3 Vertical cut (azimuth 0°) farfield of the 2 element 20/15/10m TDL beam in free space

In very much the same way as with the parasitic reflector (or director) elements of a TDL beam arrangement can low impedance series resonances be established in the feeder element through a balanced transmission line of proper length connected to the feeder element terminals.

The orthogonal orientation of the feeder line and the reflector stub depicted in Fig. 1 is simply for modeling reasons. Any other accommodating line orientation will be fine as coupling between feed line and feeder element or reflector stub and reflector element will be negligible.

Resonance in each of the 20/15/10m bands are established by means of a feeder line (Zl=300Ohm) of length 11.60m/38.0ft (v=1.0). The resulting low input impedance (Zi=100Ohm) for the 3-band 20/15/10m TDL beam is shown in Fig. 4. A 2:1 balun at the feeder input will allow operation into or from asymmetric 50Ohm coaxial cable.

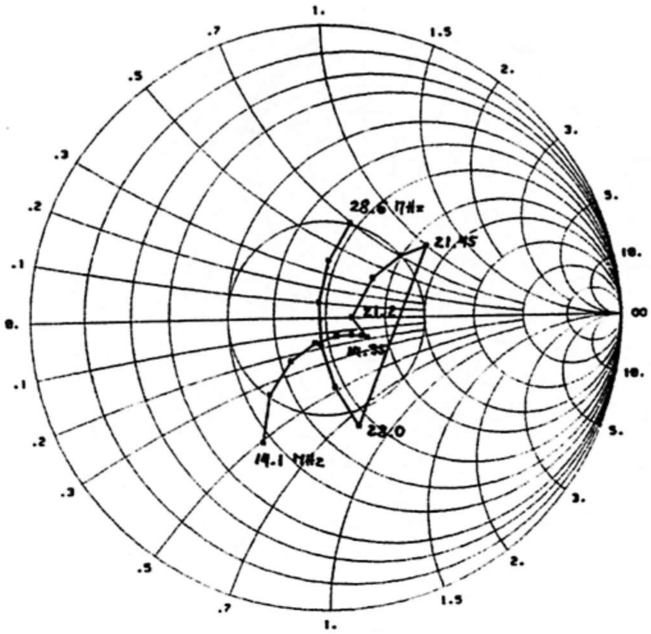

Fig. 4 Free space input impedance of the 2-element 20/15/10m TDL beam normalized to 100Ohm

## 4. The 2-Element TDL Beam for 20/15/10m over finite ground

If operated over average finite ground as shown in Fig. 5 only the vertical cut farfield pattern will change according to the center height of the TDL beam.

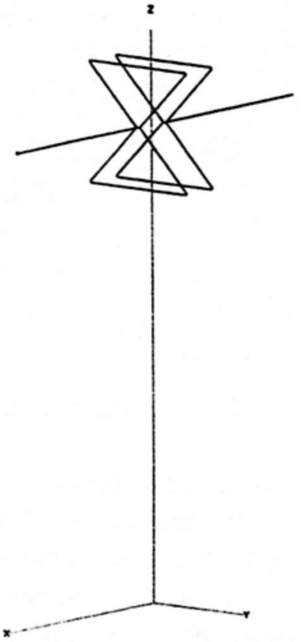

Fig. 5 Geometry of a 2-element 20/15/10m TDL beam at height of 21.3m/70ft

Input impedance and the azimuth farfield pattern Fig. 6. remain basically unchanged.

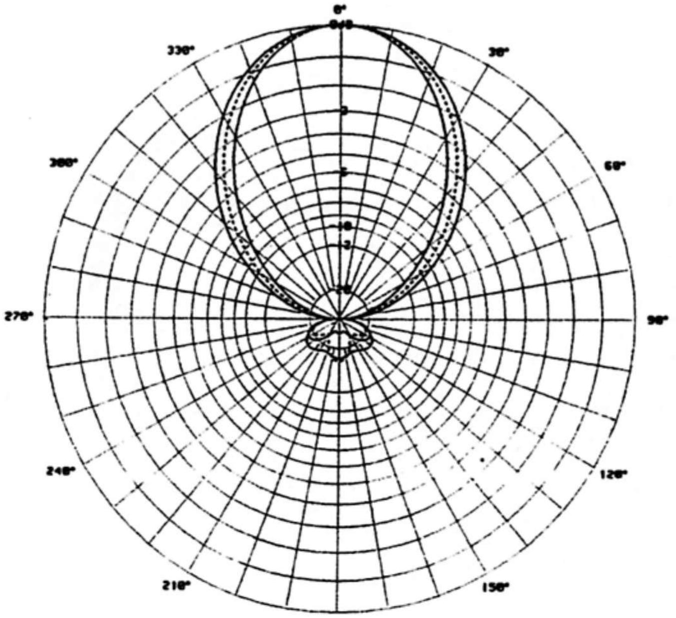

Fig. 6 Horizontal cut far-field (elevation 9°) of a 2-element 20/15/10m TDL beam at 21.3m/70ft

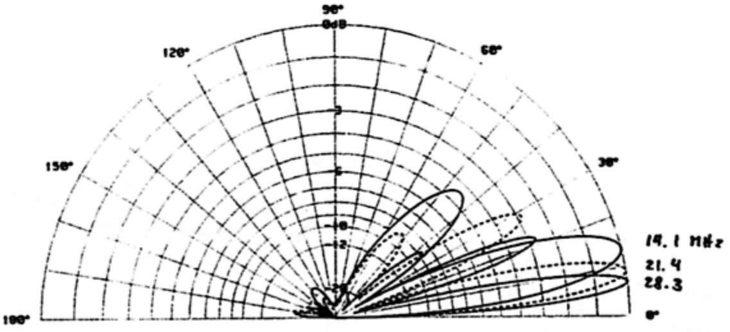

Fig. 7 Vertical cut farfield (azimuth 0°) of a 2 element 20/15/10m TDL beam at 21.3m/70ft

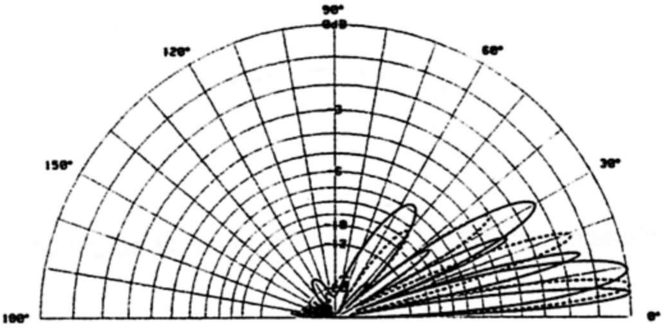

Fig. 8 Vertical cut farfield (azimuth 0°) of a 2-element 20/15/10m TDL beam at 30.5m/100ft

## 5. The 2-Element 5-Band TDL Beam for 20/17/15/12/10m

Because of the harmonic frequency relationship of the classic 20/15/10m bands the design of a 3-band TDL beam for these bands seems rather obvious and simple. The real challenge rests with a 5-band TDL beam which in addition covers the 17/12m WARC bands with the very same geometrical structure.

Even though the two WARC bands are not exactly harmonically related to the 20/15/10m bands they happen to be allocated only slightly off the 5th and 7th harmonics of 80m band frequencies, with the narrow 17m band being the farthest off. It is this near harmonic relationship in conjunction with the closed-loop design principle that lets the TDL beam tick on the WARC bands too, at only slightly compromised performance. In order to accommodate the two additional resonances on the 17/12m bands the set of reflector element stub and feed element transmission line for the 5-band 20/17/15/12/10m beam need to be considerably longer than for the 3-band 20/15/10m as can be seen from Fig. 9. Through computer optimization[4] the length of the reflector stub was determined to 33.10m/108.6ft while the feeder requires a length of 32.40m/106.30ft. The 5-band performance of the 2-element TDL beam is summarized in Fig. 9 through Fig. 12. Some minor degradations in front/rear ratio and SWR can be observed on 17m which are more than offset by the convenience and overall performance of the 2-element TDL beam on all HF DX bands in the 14 - 30 MHz range.

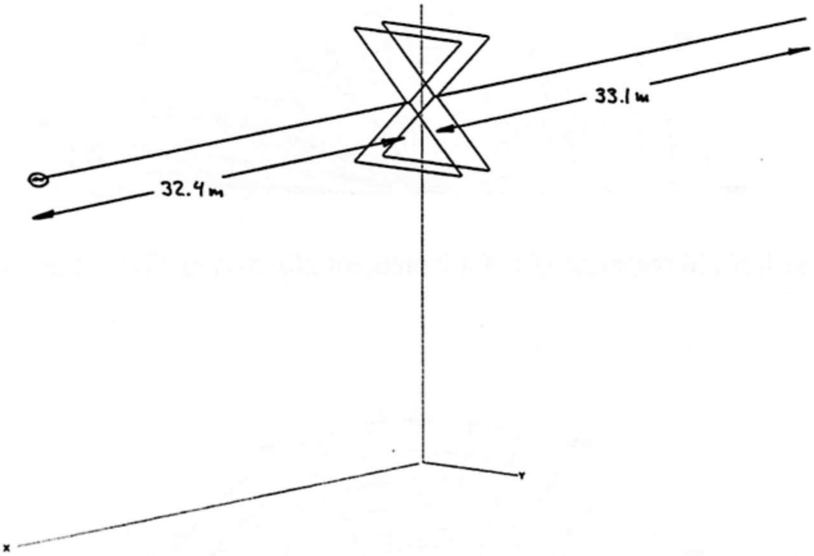

Fig. 9 Geometry of a 2-element 20/17/15/12/10m TDL beam at height of 21.3m/70ft over ground

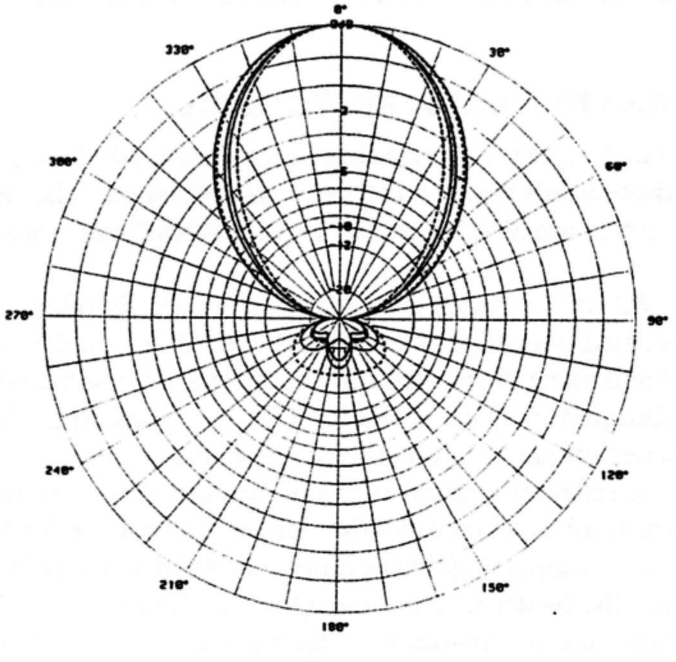

Fig. 10 Horizontal cut farfield (elev. 9°) of a 2-element 20/17/15/12/10m TDL beam at 21.3m/70ft

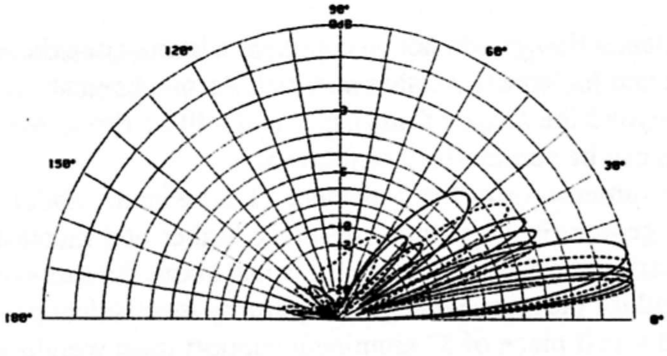

Fig. 11 Vertical cut farfield (azim. 0°) of a 2-element 20/17/15/12/10m TDL beam at 21.3m/70ft

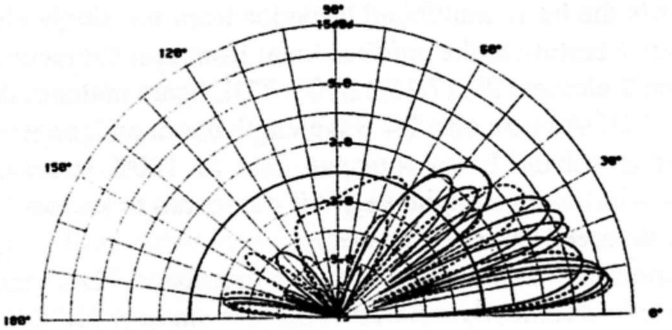

Fig. 12 Vertical cut gain function (azimuth 0°) of the 2-element 5-band TDL beam at 21.3m/70ft

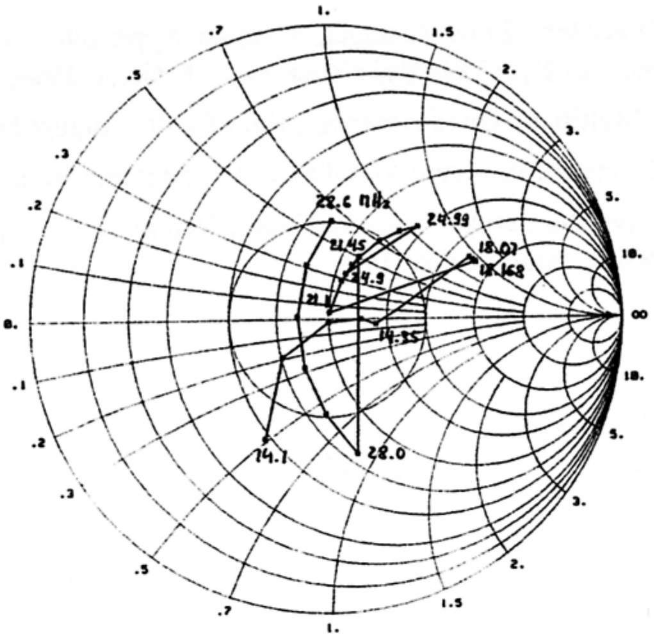

Fig. 13 Input impedance of the 2-element 20/17/15/12/10m TDL beam normalized to 100Ohm

## 6. Windload and Weight

The picture of a new antenna design will not be complete without considering the practical aspects of windloading, weight and inclement weather survival. As mechanical and constructional details of the TDL boom are beyond the scope of this paper and will be discussed elsewhere the quintessential mechanical facts can be summarized as follows.
Even though the outline dimensions of the 2-element TDL beam are about 1.5 that of a 2-element 20m Quad at twice the geometrical aperture, (resulting higher and increasing gain) the effective 0.75sqm/8.2sqft windload of the 5-band TDL beam is just about the same or slightly less than that of a 5-band Cubical Quad for the same bands. A very sturdy mechanical construction made of 1.5" fiberglass spreaders and a 15ft piece of 3" aluminum support mast weighs approximately 20.0kg/ 45.0lbs which is about 20% less than a comparable 2-element Quad.

## 5. Conclusion

As the TDL beam inherits the basic multiband behavior from the single element TDL antenna it extends the multi resonance feature to the unidirectional front/rear characteristics without employing lossy traps. While the 2-element 20/17/15/12/10m TDL beam matches the performance of a 3-element monoband YAGI-UDA beam on a 1/4 wavelength boom on 20m it outperforms the 5-band Cubical Quad and other multiband beam antennas. Due its 100% structure efficiency the TDL beam offers relative low windload and light weight if compared to known 5-band beam antennas. In contrast to the widely favored log-periodic antenna which behaves like a spatial wideband bandpass filter with known undesirable side effects, the true multiband TDL beam acts as spatial comb filter with narrowband teeth specifically tailored to the five amateur HF DX bands.

## References

[1] R. Anders, "The Twin-Delta Loop Antenna, A Novel Approach to the Ultimate Multiband Antenna, Part I", ACES Newsletter, Vol. 11, No. 1, 1996, pp. 28-33.

[2] W. Boldt, "A New Multiband Quad Antenna", Ham Radio, August 1960

[3] H.F. Rückert, "A Different Multiband Aerial System", Amateur Radio, April 1978

[4] I-NAC-3, "Interactive Numerical Antenna Code", Version 2.0, Applied Electromagnetics Engineering, Atlanta, GA, 1996.

# BOOK REVIEW

## Parallel Computing, Theory and Practice

Publisher: McGraw Hill, 1994

Author: Michael J. Quinn

Reviewer: R. Perez

With this review we open a series of three reviews. The series deals with parallel computing which is a prevalent technology in computational methods. This subject, I believe, is extremely important for computational electromagnetics, since it is widely believed that parallel computing holds one of the keys to significant advancement in applied computational electromagnetics. Furthermore, it is widely concluded in many technical circles that future high-end personal computer architectures will be of a parallel architecture nature, since the future demands for voice, video, and data will outstrip the capabilities of presently used computer technologies for personal computers. This review will deal primarily with the architectures of parallel computing. In the next issue of the ACES Newsletter, we will review another book that emphasizes the mathematical/programming issues of parallel computing. In the last issue of this series, which should appear in the July 97 Newsletter, we will review a book that addresses fundamentally the development of algorithms that can be useful in computational electromagnetics.

The book is divided into thirteen (13) chapters and three (3) appendices and is written at the introductory level; so it is suitable for many who are experimenting for the first time with this computer technology and who are thinking on exploiting it for electromagnetic applications. It must be remembered that to efficiently make use of parallel computing, you not only need a parallel architecture but the user must develop sufficiently robust parallel algorithms that are suitable for that particular architecture. One of the objectives of the book is to address aspects of this important issue. Each chapter is followed with useful references and a series of exercise problems.

Chapter 1 provides a general introduction to the exploration of parallel algorithms. It addresses some of the scientific problems that could benefit from parallel computer modeling, and some of the history of the last 20 years in the evolution of parallel computing. Some terminology (e.g. the difference between pipelining and parallelism) is discussed.

Chapter 2 provides a mental break from the sequential Von Neumann model. The author introduces the concept of parallel random access machine (PRAM) model of parallel computation. The PRAM models allows the parallel algorithms designer to address processing power as an unlimited resource, much as programmers do with virtual memory. The PRAM model is very simplistic since it ignores the complexity of interprocessor communication, however, it gives the advantage that the developer can focus on the parallelisms inherent in a particular application.

Chapter 3 introduces three (3) important models of parallel computation and the several related computer designs. The models are processor arrays, multiprocessors, and multicomputers. Each of these models have been used in current commercial computers. Within processor organizations, the author covers meshes, binary tree, hypertree, pyramid, hypercube, cube connected cycles, shuffle-exchange and de Bruijin. Multiprocessor machines, multicomputer machines, such as Thinking machine CM-5 and the Intel Paragn XP/S are described. The chapter ends with some terminology description (e.g. the Amdahl effect).

Chapter 4 describes six (6) of the languages used to program parallel computers and how these languages address the problem of parallel process allocations and coordination. These are imperative languages though extensive research is also presently focusing on logic programming and functional programming languages.

Chapter 5 covers four (4) problems relating to implementing algorithms on parallel computers: the static mapping of processes to processors on multicomputers and processor arrays, the dynamic load-balancing on multicomputers, task scheduling on multiprocessors, and ways in which parallel processes can be deadlocked.

Chapter 6 develops parallel algorithms to solve three (3) simple problems. The first problem is to perform a reduction operation, the second is to compute the prefix sums of a list of numbers, and the third is to broadcast a value from one processor in a parallel computer to all other processors. In the course of developing parallel algorithms to solve these problems, the book discusses some valuable design strategies that can be put to good use when considering more complex problems. Matrix multiplication is fundamental to most numerical algorithms and to computational electromagnetics.

Chapter 7 examines several parallel algorithms used to perform matrix multiplication. The chapter first reviews the standard sequential matrix multiplication algorithms. Proof is shown that matrix multiplication on a 2-D mesh connected SIMD (single input multiple data stream) model has only a limited complexity, and a description of an optimal matrix multiplication algorithms for this model is described. The chapter also describes matrix multiplication on multiprocessor machines. These methods can parallelize the sequential algorithms on this model. Finally the chapter develops two parallel matrix multiplication algorithms for hypercube multicomputers.

The discrete fast fourier parallelization methodologies are described in Chapter 8.

Chapter 9 surveys the parallelization of algorithms for use in solving systems of linear equations. Many computational electromagnetic algorithms will eventually take the form of linear equations, and such systems of equations are ideal for solving in parallel computers. The parallelization of back-substitution algorithms for solving upper triangular systems, odd-even reduction, tridiagonal systems, and the well known gaussian elimination algorithms are discussed. The parallelization of the Jacobi and Gauss-Seidel algorithms and the conjugate gradient method is also discussed.

Chapter 10 discusses sorting algorithms. Sorting is one of the most common activities performed on serial computers. Many algorithms incorporate a sort so that information may be processed efficiently. It is also used widely in data permutations on distributed memory computers. These data-movement operations can be used to solve problems in grapyh theory, computational geometry, and image processing in optimal or near optimal time. The chapter describes a series of parallel internal sorts algorithms for processor arrays, multiprocessor and multiprocessor architectures.

Chapter 11 covers dictionary operations. The chapter describes parallel algorithms used to solve the problems of searching an ordered table for the existence of particular keys, inserting keys into an ordered table, and deleting keys. Efficient sequential algorithms have been developed to allow dictionary operations to be performed in logarithmic time relative to the size of the table, an enormous improvement over linear time needed if keys were kept in an unordered list. Search algorithms operate on elements, called keys, stored in a table of finite size. The chapter studies the inherent complexity of parallel search algorithms.

Chapter 12 examines a number of parallel algorithms developed to solve problems in graph theory. These problems relate to searching graphs and finding connected components, minimum cost spanning trees and shortest paths in graphs.

Chapter 13 addresses combinatorial search. Combinatorial algorithms perform computations on discrete, finite mathematical structures. Combinatorial search is the process of finding "one or more optimal solutions in a defined problem space". This chapter surveys the parallelization of divide and conquer, branch and bound, and alpha-beta algorithms.

The book is recommended as a good balance of theory and practice to parallel computing. If designing parallel programs for computational electromagnetics is in your horizon, and you need to get started with some fundamentals, here is a suitable book that you can use. It has been useful to me.

# Review of the Method of Moments Numerical Techniques MAXSIM_F & MAXSIM_T

L.B. Gravelle+ and J.-P. Estienne*

+Scientific Research & Modeling, Ottawa, Ontario, Canada
*MATRA Cap System, Toulouse, France

*Abstract* - **A frequency model and an implicit time domain model for the analysis of wires and conducting surfaces are presented. The models are based on the method of moments numerical technique using, for the time domain, Lagrange second order time domain basis functions which plays an important role on the road to stability. With this type of formulation, the method of moments can finally be utilized for the analysis of fast transients directly in the time domain for structures including wires and surfaces. The models' stability and accuracy are presented for complex systems including conducting surfaces, transmission lines, non-linear loads, open cubes and satellites.**

## 1. INTRODUCTION

The aim of this article is to present a numerically stable technique able to calculate stationary and transient currents and fields associated to wire and surface structures including junctions between wires and surfaces. This numerical technique will be able to analyze the electromagnetic response of three-dimensional objects to an impinging field and/or to a conducted source (voltage or current source). It is very well suited to the analysis of antennas, circuits as well as field penetration/coupling onto various structures (satellites, air planes, equipment, ...).

The formulation is an integro-differential equation technique for the analysis of thin wire/surface structures. Through the use of the method of moments (MOM), the integral equation, defining the time-dependent current distribution on a wire/surface structures, is reduced to a system of equations to be solved simultaneously for each time/frequency steps (as an initial valued problem for transient analysis).

The first development in the time domain MOM area is due to Miller and Burke in the 70's. They developed a transient scattering model [1] solving directly in time, via the MOM, the scattering of thin wire structure. This was the first time that the E.F.I.E. (Electric Field Integral Equation) was solved using the MOM in the time domain. The scatterer was defined as a collection of interconnected wires. Kirchoff's law was not strictly applied at multiple wire-node junction locations, since the current was expanded at the center of each segment as second order Legendre polynomial in both time and space. Except for an extension of the Miller model to surfaces [2] (continuity of currents on the edges wasn't forced), there was no significant progress during the next two decades.

Recently, with the new capabilities of the modern digital computers, advances in electromagnetic computational methods have been made possible. Rao [3] presented an equivalent solver for surfaces only, which uses edge functions and first order expansion in time. The algorithm is of first order accuracy in time with edge functions, leading to an iterative explicit algorithm, a marching-on-in-time solution. Unfortunately, instabilities appear very early . For this reason, it is not applicable to large structures such as satellites. Furthermore, the addition of wire is not reported.

In the following section the theory behind the model will be briefly presented

## 2. THE THEORY BEHIND THE MODEL

The type of formulation used is based on the E.F.I.E. for which three-dimensional objects may be represented by electrically small elements where the current information is concentrated in one plane. Within wire structures, the total current on the wire is concentrated at its center, therefore when applying the tangential electric field boundary condition on the surface of the wire, no singularities occur at the field evaluation points. For the case of surface structures, the total inside and outside surface currents are concentrated on an infinitely thin surface, therefore eliminating instability that would be induced by the very small discretisation of the metal thickness.

Starting with Maxwell's equations, we first derive Faraday's equation. In Faraday's equation, the electric field E is expressed in terms of the scalar potential $\phi$ and the magnetic vector potential **A** as follows:

- time domain

$$\vec{E}(\vec{r},t) = -\nabla\phi - \frac{\partial}{\partial t}\vec{A}(\vec{r},t) \qquad (1a)$$

- frequency domain

$$\vec{E}(\vec{r},t) = -\nabla\phi - j\omega\vec{A}(\vec{r},t) \qquad (1b)$$

where the magnetic vector potential, A, is defined via the current distribution vector, **J**, and the scalar potential, $\phi$, via the charge density scalar, $\rho$. By introducing some basic assumptions with respect to wires:

- The radial component of the current is uniform
- The currents are localized on the external surface of the wire (skin effect)

and surface:

- The internal and external surface currents are concentrated on a mathematically thin surface,

the volume integrals may be reduced to contour integrals for wires and surface integrals for patches. Thus Faraday's equation may then be re-written as an integro-differential equation, referred to in the literature as E.F.I.E.:

- time domain

$$\vec{E}(\vec{r},t) = -\frac{1}{4\pi\varepsilon}\vec{\nabla}_s\int_{S(r)}\frac{\rho(\vec{r}',\tau)}{R}\,ds' - \frac{\mu}{4\pi}\frac{\partial}{\partial t}\int_{S(r)}\frac{\vec{J}(\vec{r}',\tau)}{R}\,ds' \qquad (2a)$$

- Frequency domain

$$\vec{E}(\vec{r}) = -\frac{1}{4\pi\varepsilon}\vec{\nabla}_s\int_{S(r)}\rho(\vec{r}')\frac{e^{-jkR}}{R}\,ds' - j\omega\frac{\mu}{4\pi}\int_{S(r)}\vec{J}(\vec{r}')\frac{e^{-jkR}}{R}\,ds' \qquad (2b)$$

Equation (2) presents an important disadvantage, there are two **J** & $\rho$ for patches) to solve which, in computer terms, translates into twice the memory requirements and a fourfold increase in CPU time. We may relate the charge density to the current density through the use of the equation of continuity, thus reducing this two vector unknown system to a one vector unknown system.

Applying the boundary conditions characterizing the problem at hand we are able to derive the appropriate formulation. For this application we know that the total tangential electric fields on the surface of a perfectly conducting metal is zero,

$$\vec{E}^T_{//} = \vec{E}^I_{//} + \vec{E}^S_{//} = 0 \qquad (3)$$

where T denotes the total electric fields, I the incident fields and S the scattered fields.

Next basis functions are required. The definition of an appropriate basis function is a crucial part of the model development, the function must be able to follow the wire current variations as closely as possible while remaining as simple as possible. A complex function will lead to an non-derivable formulation or a formulation involving complex, time consuming numerical integration.

The temporal approximation should be of the second order since there is a double time derivative of the unknown (a first order function is possible but lead to less accurate results, finite difference would be required). As for the spatial approximation, a first order function was chosen to limit the complexity of the formulation while still representing the surface current fairly accurately.

In order to follow the surface current variations, the object is discretised into sub-sections. Within each sub-section the current is approximated by the chosen basis function leading to a system of equations. This system of equations is defined by the inter-relationship of each sub-section unknown current.

The technique of moments enables us to solve an integro-differential system by transforming the problem into a linear system. The linear system is obtained by applying the boundary conditions coupled with a testing procedure. The weighting functions chosen for the present application are Dirac functions for the temporal content and a Galerkin type for the spatial content:

- spatial weighting functions => basis functions
- Temporal weighting functions => Dirac functions

The testing procedure consist of taking the inner product of the E.F.I.E. with the weighting function, **g** :

- time-domain

$$\left\langle\frac{\partial}{\partial t}\vec{E}^I,\vec{g}\right\rangle = -\left\langle\frac{\partial}{\partial t}\phi,\vec{\nabla}\cdot\vec{g}\right\rangle + \left\langle\frac{\partial^2\vec{A}}{\partial t^2},\vec{g}\right\rangle \qquad (4a)$$

- Frequency domain

$$\left\langle\vec{E}^I,\vec{g}\right\rangle = -\left\langle\phi,\vec{\nabla}\cdot\vec{g}\right\rangle + \left\langle j\omega\vec{A},\vec{g}\right\rangle \qquad (4b)$$

where the inner product is defined as

$$\left\langle\vec{f},\vec{g}\right\rangle \equiv \iint_s \vec{f}\cdot\vec{g}\,ds \qquad (5)$$

$\vec{f}$ being the E.F.I.E. operator.

In time domain analysis, the final system of equations is obtained by separating the surface current contributions previously calculated ($t < t_v$) from the unknown node/edge currents at time $t_v$. This will result in an iterative numerical solution of a matrix Z multiplying the unknown vector **J** of which the product equals the source vector (impinging fields, current and/or voltage sources and the radiated wire/patch current contributions).

In frequency domain, a simple matrix inversion multiplying the source vector leads to the solution for small applications and a biconjugate gradiant for more complex situations.

## 3. NUMERICAL RESULTS: MAXSIM_T

The case studies presented in this section aim to present the good correlation between this time-domain MOM model and available data in the literature, the stability of the simulations as well as the possibility of analyzing complex structures including wire-to surface junctions, non-linear components and time-delayed controlled sources. Analyzed are illuminated dipole antennas and surface plate, the radiation from an electrostatic discharge and two transmission lines over a finite ground plane with non-linear elements.

### *3.1. ILLUMINATED DIPOLE ANTENNA*

As a first analysis, we present the current calculated at the center of a 1 meter dipole antenna illuminated by an electric field impinging at a 45 degree angle to the antenna. The source is a gaussian type defined as $E_I(t) = A*\exp(-\alpha^2*(t_c-t)^2)$ with A=2340V/m, $\alpha$=3.63E09 and $t_c$=2.5ns. The time signature of the dipole's center current has the same form as found in the literature [5], the level vary slightly due to the fact that the field strength and the dipole wire radius were not made available.

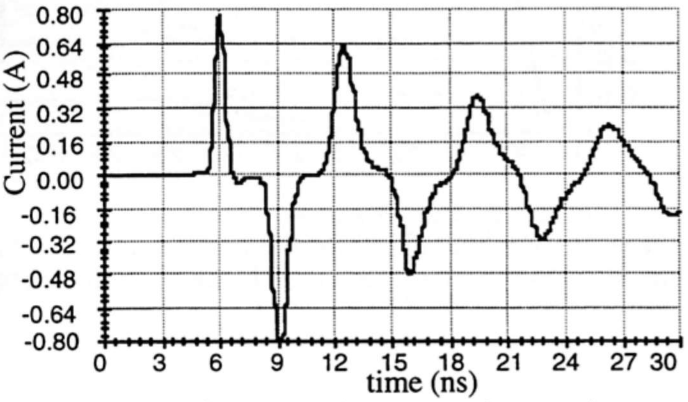

Figure 1. Current at the center of a gaussian illuminated 1m dipole antenna.

### *3.2. ILLUMINATED SURFACE PLATE*

Next we present the current calculated at the edge of a 2 meter by 2 meter conducting plate. The plate is illuminated by an electric field impinging at a 90 degree angle to the plate with a gaussian time signature centered at 80ns and an $\alpha$ constant of 5.0E07. In previous time-domain MOM models, [3] & [6], high instabilities where encountered early in the analysis ([6] remedies the problem with the use of FIR filters). The results from our model shows a very stable analysis partially due to the temporal basis function.

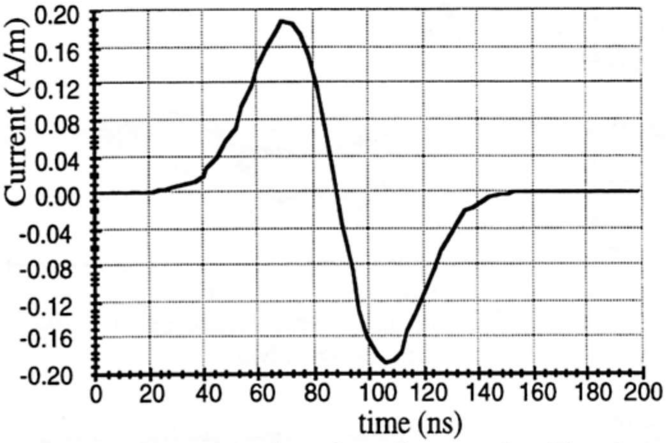

Figure 2. Current at the edge of a gaussian illuminated plate.

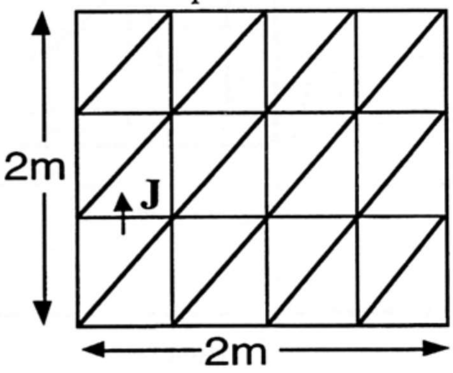

Figure 3. The geometry of the plate.

### *3.3. ESD RADIATED FIELD*

From available ESD current measurements the radiated electric field were calculated assuming a dipole as the current carrier and thus the radiator. The current signature, see the inset graph in Figure 5, was defined with the use of an ESD and a rounded step functions, it's peak amplitude is 11 A with a 1ns rise time. The electric field was calculated at 1.5m away in broadband. Shown in Figure 4 are the result of the measurements and the dipole model presented by Ma [7], and in Figure 5 the result of the MOM model. The difference between the experiment and the models is due to simplicity of the chosen dipole radiator, nevertheless the results between the experiment and the MOM model are very similar.

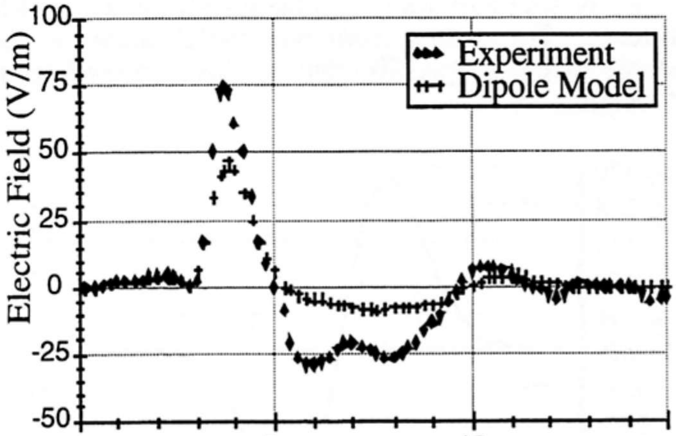

Figure 4. ESD radiated field measurements and model from Ma.

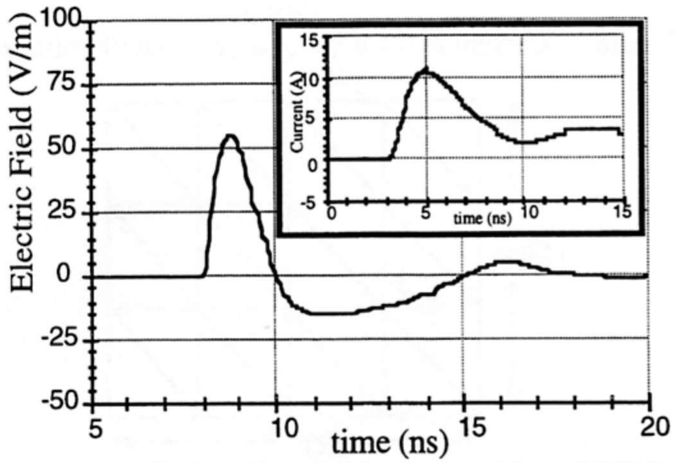

Figure 6. ESD radiate field calculated from MOM, on the inset graph the ESD current time signature.

### *3.4. TRANSMISSION LINES OVER FINITE GROUND PLANE*

A validation of the model for a complex system is presented in figures 6 through 8. The system analyzed consist of a 10x4cm plate discretised into triangular patches onto which is connected two transmission lines represented by wires of 1mm diameter and 2cm long. The transmission lines are coupled by induction as well as through a voltage controlled voltage source with a time delay, $V_L(t) = 10000*R_S*I_S(t\text{-}160\text{ns})$; the source resistance, $R_S$, is set to 1m$\Omega$; the load resistance, $R_L$, is set to 100$\Omega$; the voltage source is a pulse with a rise and fall time of 10ns and a pulse width of 30ns centered at 35ns; and the non-linear inductance is a step function starting at 20nH with a fall time of 30ns centered at 100ns (the intrinsic inductance of the transmission lines is also 20nH). The stability of the time domain method of moment model is well demonstrated by the analysis of this system.

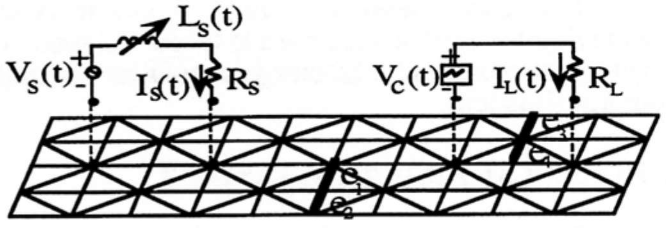

Figure 6. Transmission line structure.

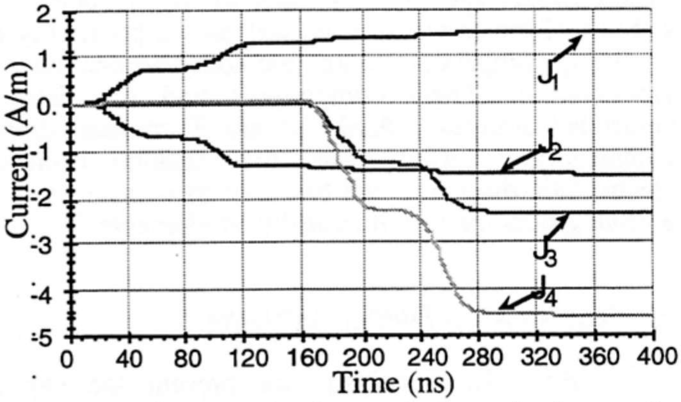

Figure 7. Currents on the patch discretised ground plane.

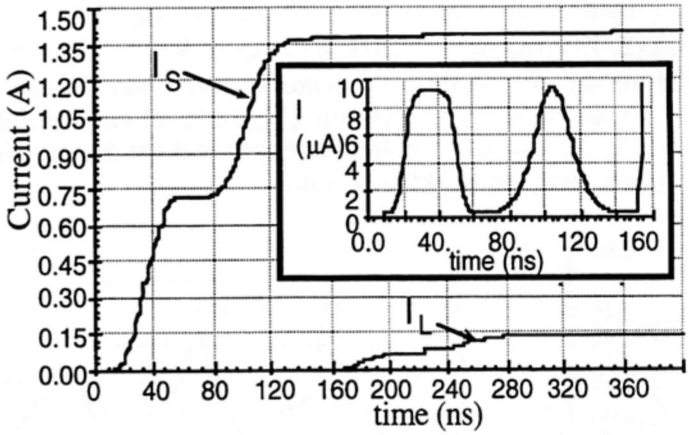

Figure 8. Currents on the source and load transmission lines (TLs), on the inset graph is shown the induced current on the load TL due to the current of the source TL.

### 4. NUMERICAL RESULTS: MAXSIM_F

Three case studies are presented in this section. The idea is to present comparisons between measurements and simulated results from the frequency domain MOM model. Two test configuration are shown, an open face cube with an internal transmission line and a satellite excited via an external wire loop. As will be seen the results are in agreement within at most 5dBs.

### *4.1. THE OPEN FACE CUBE*

The first case consist of a 1m steel cube with one of its face open, a wire injection loop excited via a voltage source is connected to two opposite faces of the cube. Within the cube is a transmission line grounded to the bottom face of the cube on which the coupling currents will be measured and analyzed. See Figure 9. The frequency of interest are 10, 40, 60 and 100 MHz.

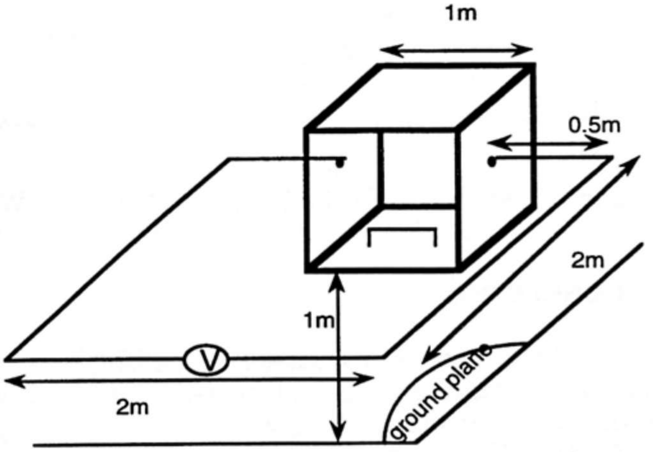

Figure 9. The Open Cube Configuration.

The results of the analysis and measurements on the internal transmission line are shown in the following table.

| | Current in R=1009Ω | | |
|---|---|---|---|
| Frequency | Measure | Simulation | Variation |
| 10 MHz | 45.0 dBµA | 45.4 dBµA | Δ=0.4 dB |
| 40 MHz | 49.0 dBµA | 54.4dBµA | Δ=5.4 dB |
| 60 MHz | 52.0 dBµA | 58.0 dBµA | Δ=6 dB |
| 100 MHz | 75.5 dBµA | 75.6 dBµA | Δ=0.9 dB |

Considering that the magnitude of the currents on the internal wire are very small compared to the injected currents, which makes it more difficult for the numerical technique, the results are in close agreement. Furthermore the frequencies of 40 and 60 MHz correspond also to the resonant frequencies of the test chamber.

Shown in Figures 10 & 11 are comparisons of the magnetic fields inside and on the top cover of the cube at 100 MHz. Again the results are in harmony with a variation on the order of 2-4 dBs. Another point of validation are the signature of the magnetic field:

- inside the cube the fields increases in the direction of the open face
- on the top cove of the cube the fields peak at the middle and decreases as it approaches the edges

as it should.

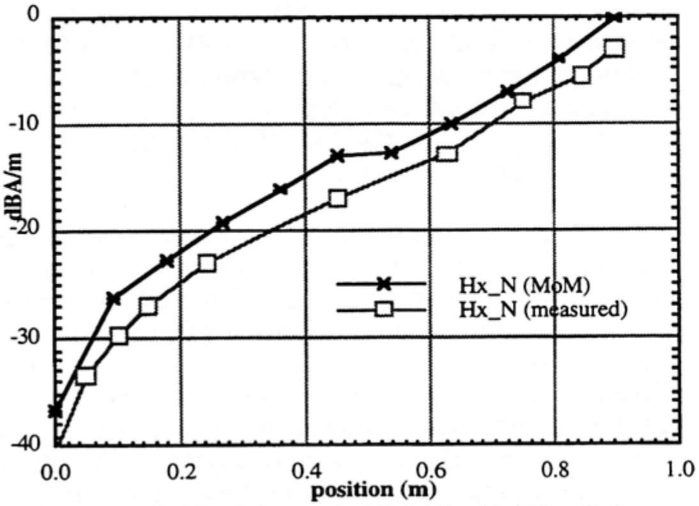

Figure 10. The Magnetic Field Inside The Cube at 100 MHz.

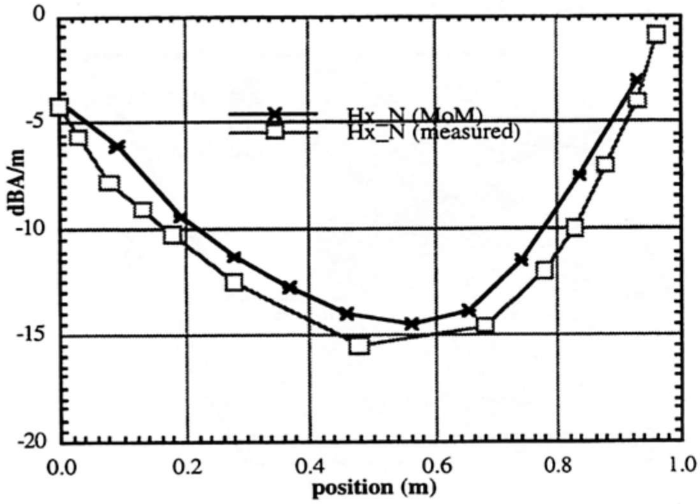

Figure 11. The Magnetic Field On The Top Cover Of The Cube at 100 MHz.

### *4.2. THE MAROTS SATELLITE*

The second test case consist of the analysis of an electrical 1 to 1 scale model of the MAROTS satellite with a configuration as shown in figure 12.

The results of the simulation depend on the precision at which the model represents the actual physical satellite. In this case the complex structure of the satellite made it such that some parts of the model were not in perfect accordance with the physical object. For example the reinforcement bars and the legs of the antenna were modeled as thick wires. The meshed model of the satellite consisted of about 2000 elements (triangular patches and wires).

Even with these approximations, the comparison between the simulation and the measurements were in accordance with respect to the signature of the currents and fields with a difference of only a few dBs in magnitude. The analysis were performed at frequencies of 10, 40, 60 and 100MHz. In general the electromagnetic response of the system conformed. Around the complex parts, namely near the antenna support and the top of the main body, the results were not at their best.

The correlation between measurements and simulation of the distributed currents around the injection wire loop was very good for all frequencies with a maximum variation of only 1 dB, see Figure 13 for an example of the results. To model the wire loop dielectric and the wooden support for the loop, a distributed impedance consisting of resistance and inductance were added to the wire segments in order to simulate the propagation constant within the wire. The estimated propagation constant was evaluated to around 0.84 the speed of light. In the new version of MAXSIM_F, surface dielectric are now modeled for both wires and patches.

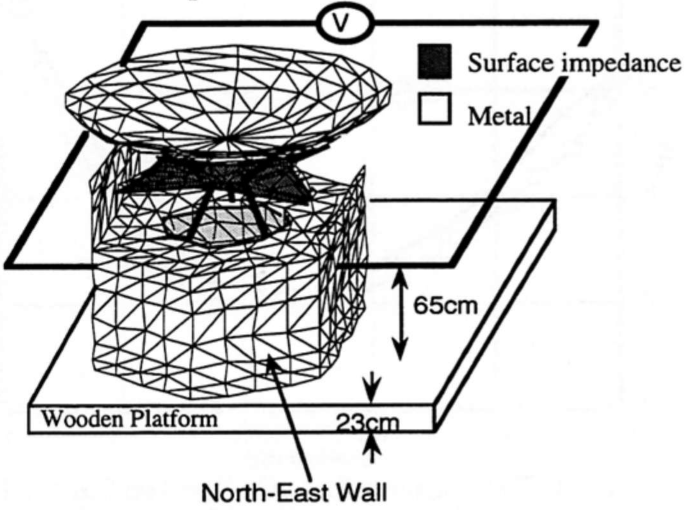

Figure 12. Test Configuration Of The MAROTS Satellite.

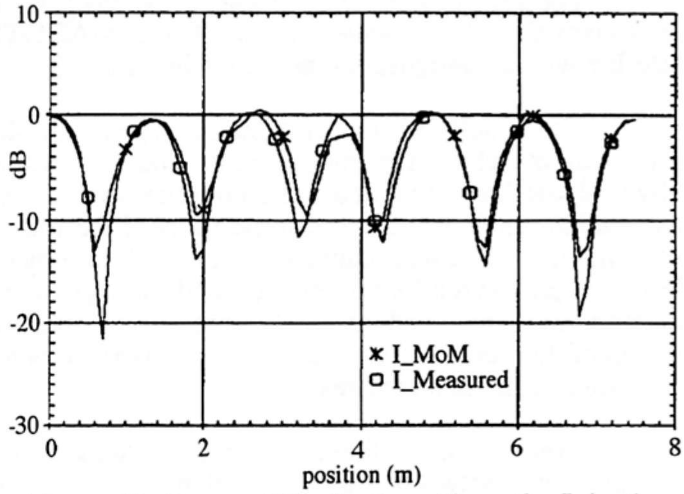

Figure 13. Current Distribution Along the Injection Loop of the Satellite at 100 MHz

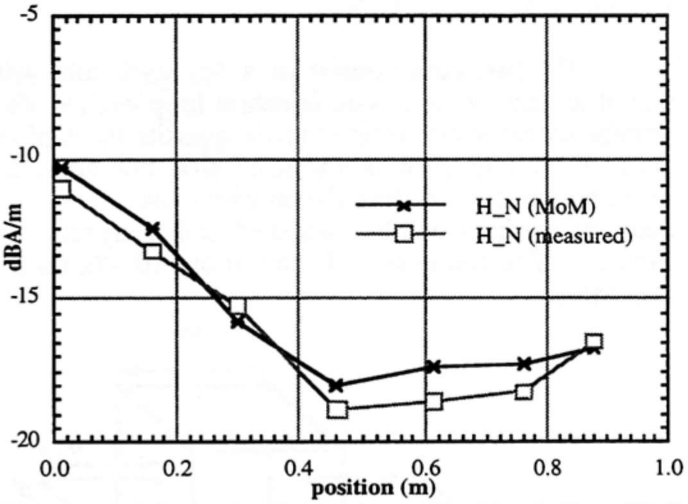

Figure 13. Magnetic Field Along The North-East Wall Of The Satellite at 40 MHz

## 5. CONCLUSION

In the above discussion MAXSIM_T, a new numerical time domain boundary integral method, was reviewed along with it's frequency domain counterpart MAXSIM_F. The methods demonstrate very stable results. We demonstrated its utility with a survey of various applications. Basic examples were chosen to validate the MOM model. They also demonstrated the accuracy, convergence and stability properties of the method. Complex structures were analyzed to present the versatility of the models.

This type of time-domain formulation is very well suited for the analysis of antennas for which their response to transient electromagnetic excitation are still not well understood. Moreover with this method, the analysis of antennas or circuits loaded with discrete elements (linear or time-dependent) is readily obtained. Previous method solving such time-domain problems were analyzed via a frequency domain type of formulation along with the inverse Fourier transform. This yields a tedious and time consuming simulation for non-harmonic excitations or elements. The direct technique offers greater efficiency than transformation techniques (FFT and $\mathrm{FFT}^{-1}$), the ability to treat non-linearities, the convenience of wide broad-band information from a single calculation and the resonances of complex objects.

As opposed to other methods, finite difference and finite elements, for which the total region needs to be discretised, the method of moments is a numerical technique that is well adapted to three-dimensional geometries.

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# SURVEY OF STATE-OF-THE-ART IN COMPUTATIONAL ELECTROMAGNETICS METHODS AND RELATED TECHNIQUES

## Introduction

The following is a technical survey to establish the state-of-the-art in the application of advanced Computational Electromagnetics (CEM) tools and related methods by commercial industry. The survey is being conducted in conjunction with research co-sponsored by the US Air Force. By exploring the needs and wants of potential users of advanced CEM analysis tools, we intend to compile information about:

- The rate of adoption of advanced CEM analysis tools by different segments of commercial industry
- External trends and influences that will accelerate/retard the adoption of CEM analysis
- Suitability of currently available CEM software to the needs of commercial industry
- Directions of improvement in CEM tools.

All survey responses will be kept entirely confidential. Your individual response will be merged into an anonymous responses database. We will not attribute any published responses to you, or to your company. We also will keep your identity strictly confidential, will NOT provide any information to be used for telemarketing, or sold or rented to junk-mail list compilers.

Your response to this survey will help to establish important trends and assist in identifying the needs of users with regard to the development of advanced CEM tools and their application to broad computational engineering environments into the year 2000 and beyond.

To participate, fill out the following Survey Questionnaire and mail it to **ANDRO Consulting Services, P. O. Box 543, Rome, NY 13442-0543**. You can also take the survey via the internet at **http://www.auragen.com/icemes**. If you have any questions, please e-mail them to us at, ISGsurvey@AOL.com.

Although this survey is primarily directed at industry and commercial users of CEM tools, we are also encouraging the participation of representatives from government agencies and academic institutions.

The survey should take about 15-20 minutes to complete. Your inputs will not only help shape the future of CEM methods, tools and techniques, but will also assist our community in identifying and implementing advancements that will make CEM analysis more efficient and productive.

**(Please turn to the next page.)**

## Survey Questionnaire

### 1. Information About Your Current Electromagnetic (EM) Analysis & Testing Methods

For the first three questions, check:

- only the "Do Today" box if you do testing today, but plan to discontinue within three years.
- only the "Will do in three years" box if you are not doing testing in this area today, but plan to implement within three years.
- both boxes if your company does EM testing in the indicated area today and intends to continue for at least three years.
- neither box if you don't do EM testing in the indicated area today and have no plans to implement within three years.

1.1 What kinds of EM ***testing*** do you do routinely?

| **Type of Testing** | **Do Today** | **Will Do 3 Years From Now** |
|---|---|---|
| 1.1.1 Concept Investigation | 1.1.1 | 1.1.1 |
| 1.1.2 Pre-Prototype & Preliminary Design Evaluation | 1.1.2 | 1.1.2 |
| 1.1.3 Finished Prototype Evaluation | 1.1.3 | 1.1.3 |
| 1.1.4 Regulatory Compliance & Certification | 1.1.4 | 1.1.4 |
| 1.1.5 Quality Control in Production Units | 1.1.5 | 1.1.5 |
| 1.1.6 Post-Production Troubleshooting | 1.1.6 | 1.1.6 |
| 1.1.7 If you've intentionally left all the boxes above empty in either column, please check the corresponding "None" box. | | |
| 1.1.8 None | 1.1.8 | 1.1.8 |

1.2 ***At what level*** does your business do EM ***analysis & simulation?***

| **Level of Analysis** | **Do Today** | **Will Do 3 Years From Now** |
|---|---|---|
| 1.2.1 System Level | 1.2.1 | 1.2.1 |
| 1.2.2 Critical Subassemblies | 1.2.2 | 1.2.2 |
| 1.2.3 Individual PC Boards, Components or Devices | 1.2.3 | 1.2.3 |
| 1.2.4 If you've intentionally left all the boxes above empty in either column, please check the corresponding "None" box. | | |
| 1.2.5 None | 1.2.5 | 1.2.5 |

1.3 ***How*** does your business do EM ***analysis & simulation?***

| Approach to Analysis | Do Today | Will Do 3 Years From Now |
|---|---|---|
| 1.3.1 Specialized EM Analysis Tools | 1.3.1 | 1.3.1 |
| 1.3.2 Circuit Modeling Software With Limited EM Analysis Capability | 1.3.2 | 1.3.2 |
| 1.3.3 Generic Mathematical Analysis Tools | 1.3.3 | 1.3.3 |
| 1.3.4 In-House Analytical Tools | 1.3.4 | 1.3.4 |
| 1.3.5 Manual Analysis | 1.3.5 | 1.3.5 |
| 1.3.6 Testing Only | 1.3.6 | 1.3.6 |
| 1.3.7 If you've intentionally left all the boxes above empty in either column, please check the corresponding "None" box. | | |
| 1.3.8 None | 1.3.8 | 1.3.8 |

1.4 Which analytic techniques do you commonly employ *(check all that apply)?*

1.4.1 _____Finite Element
1.4.2 _____Transmission Line Matrix
1.4.3 _____Finite Difference Time Domain
1.4.4 _____Boundary Element
1.4.5 _____Geometrical Optics
1.4.6 _____Shooting-Bouncing Rays/Physical Optics/Physical Theory of Diffraction
1.4.7 _____Finite Difference Frequency Domain
1.4.8 _____Method of Moments
1.4.9 _____Geometrical Theory of Diffraction
1.4.10 _____Unified Theory of Diffraction
1.4.11 _____Multiple Multipole Expansion Techniques
1.4.12 _____Finite Volume Time Domain
1.4.13 _____Finite Volume Frequency Domain
1.4.14 _____Other Time Domain
1.4.15 _____Other Frequency Domain
1.4.16 _____Other (Please specify below)
1.4.17 ____________________________________________________________

1.5 Which of the following computational EM-related (CEM) tools or environments, and circuit design/modeling tools do you use *(check all that apply)?*

1.5.1 _____ANSOFT
1.5.2 _____ANSYS
1.5.3 _____ELECTRO (Integrated Engineering Software)
1.5.4 _____BEASY
1.5.5 _____OPERA(VECTOR FIELDS)
1.5.6 _____MAGNET (INFOLYTICA)
1.5.7 _____COMPLIANCE (QUANTIC)
1.5.8 _____QUAD DESIGN Family (XTK, QUIET, Etc.)
1.5.9 _____Micro-Stripes (SONNET)
1.5.10 _____UNICAD
1.5.11 _____EMIT (SETH)
1.5.12 _____INCASES
1.5.13 _____NEC-WIN, NEC-VU, & NEC-SURF Family (antenna design & optimization modeling), Paragon/Penn State
1.5.14 _____SPICE
1.5.15 _____CARLOS-3D

1.5.16 _____BSC, Basic Scattering Code
1.5.17 _____XFDTD (REMCOM)
1.5.18 _____ I-DEAS Masters Series (SDRC)
1.5.19 _____EMAS, Code-Electromagnetic Analysis System (MacNeal-Schwendler)
1.5.20 _____HFSS, High-Frequency Structure Simulator system (HP EESOFT)
1.5.21 _____Microwave Explorer with X-Windows & OSF Motif (Compact Software)
1.5.22 _____APATCH
1.5.23 _____XPATCH
1.5.24 _____Cray's LC (FDTD)
1.5.24 _____EMA3D (Electromagnetic Associates)
1.5.25 _____ENSEMBLE
1.5.26 _____TOUCHSTONE (HP EESOFT)
1.5.27 _____LIBRA
1.5.28 _____GEMCOP (GEMACS Control Program, SEA & AE for USAF)
1.5.29 _____GEMACS (General Electromagnetic Model for Analysis of Complex Systems, USAF)
1.5.30 _____IEMCAP (Intrasystem Electromagnetic Compatibility Analysis Program)
1.5.31 _____EMCAP (Electromagnetic Compatibility Analysis Program, USN)
1.5.32 _____AAPG (Antenna-Antenna Plus Graphics, Joint Service Spectrum Center/ECAC)
1.5.33 _____NEC (Numerical Electromagnetic Code, USN)
1.5.34 _____MMACE (Microwave and Millimeter Wave Advanced Computational Environment, USAF/USN)
1.5.35 _____EMENG (Electromagnetic Engineering Environment, USN)
1.5.36 _____NEEDS (USN)
1.5.37 _____MMP
1.5.38 _____TSAR (Temporal Scattering and Response Code, LLNL)
1.5.39 _____Others (Please specify below)
1.5.40 ____________________________________________________________

1.6 If your business does ***not*** use any of the EM analysis tools listed above, please *rank the top 3 reasons (1 being the top reason) why not:*
1.6.1 _____Don't know enough about the available tools
1.6.2 _____Don't need to do extensive analysis; prototype testing is enough
1.6.3 _____Manual/spreadsheet analysis is enough
1.6.4 _____Don't have sufficient in-house technical expertise
1.6.5 _____Don't have sufficient in-house computing resources
1.6.6 _____Question ability of tools to generate accurate results
1.6.7 _____Tools are too expensive
1.6.8 _____Developed our own analytical tools in-house
1.6.9 _____Other (Please specify below)
1.6.10 ____________________________________________________________

1.7 Which of the following Mesh Generating tools do you use?
1.7.1 ____HYPERMESH (Altair Computing)
1.7.2 ____ AUTOFEA (ANSYS)
1.7.3 ____COSMOS GEOSTAR (Structural Research & Analysis Corp.)
1.7.4 ____ I-DEAS (SDRC)
1.7.5 ____Other (Please specify below)
1.7.6 ________________________________________________

## 2. EM Analysis Program Features & Benefits That You Would Like To See

2.1 In using your business's ***existing*** EM analysis tools, ***how satisfied are you*** with them?*(check 1 box in each row):*

| | **Very Unhappy (1)** | **Somewhat Dissatisfied (2)** | **Adequately Satisfied (3)** | **Very Satisfied (4)** | **Extremely Pleased (5)** | **No Opinion (6)** |
|---|---|---|---|---|---|---|
| 2.1.1 Overall accuracy of results | 2.1.1 | 2.1.1 | 2.1.1 | 2.1.1 | 2.1.1 | 2.1.1 |
| 2.1.2 Ability to process complex geometries accurately | 2.1.2 | 2.1.2 | 2.1.2 | 2.1.2 | 2.1.2 | 2.1.2 |
| 2.1.3 Ability to select different analytic techniques | 2.1.3 | 2.1.3 | 2.1.3 | 2.1.3 | 2.1.3 | 2.1.3 |
| 2.1.4 Ability to solve different parts of a problem with the same tool | 2.1.4 | 2.1.4 | 2.1.4 | 2.1.4 | 2.1.4 | 2.1.4 |
| 2.1.5 Time required to prepare model inputs | 2.1.5 | 2.1.5 | 2.1.5 | 2.1.5 | 2.1.5 | 2.1.5 |
| 2.1.6 Time required to calculate outputs (processing speed) | 2.1.6 | 2.1.6 | 2.1.6 | 2.1.6 | 2.1.6 | 2.1.6 |
| 2.1.7 Usefulness of output formats | 2.1.7 | 2.1.7 | 2.1.7 | 2.1.7 | 2.1.7 | 2.1.7 |
| 2.1.8 Ease of use by specialist users | 2.1.8 | 2.1.8 | 2.1.8 | 2.1.8 | 2.1.8 | 2.1.8 |
| 2.1.9 Ease of use by engineering-generalist users | 2.1.9 | 2.1.9 | 2.1.9 | 2.1.9 | 2.1.9 | 2.1.9 |
| 2.1.10 Disk storage requirements | 2.1.10 | 2.1.10 | 2.1.10 | 2.1.10 | 2.1.10 | 2.1.10 |
| 2.1.11 RAM requirements | 2.1.11 | 2.1.11 | 2.1.11 | 2.1.11 | 2.1.11 | 2.1.11 |
| 2.1.12 Cost to buy & maintain the needed software | 2.1.12 | 2.1.12 | 2.1.12 | 2.1.12 | 2.1.12 | 2.1.12 |
| 2.1.13 Cost to buy & maintain the needed hardware | 2.1.13 | 2.1.13 | 2.1.13 | 2.1.13 | 2.1.13 | 2.1.13 |
| 2.1.14 Other improvement opportunity #1 (please define it below) | 2.1.14 | 2.1.14 | 2.1.14 | 2.1.14 | 2.1.14 | 2.1.14 |
| 2.1.15 Other improvement opportunity #2 (please define it below) | 2.1.15 | 2.1.15 | 2.1.15 | 2.1.15 | 2.1.15 | 2.1.15 |

2.1.16 Other improvement opportunity #1: ________________________________

2.1.17 Other improvement opportunity #2: ________________________________

2.2 What kind of EM/CEM work are you involved in?
2.2.1 ____EMI/EMC (Component, subassembly or system level)
2.2.2 ____Antenna design/performance
2.2.3 ____Electrostatic Discharge (ESD)
2.2.4 ____High-Power Microwave (HPM)
2.2.5 ____Ultra-Wideband (UWB)
2.2.6 ____Other (Please specify below)
2.2.7 ________________________________________________

2.3 If you and your colleagues could design an ideal computational EM (CEM) analysis and simulation tool to use in your business, how valuable would each of the following attributes be to your business *(check one box in each row)?*

| Attribute | **Not At All Valuable To Us** | **Marginally Valuable To Us** | **Somewhat Valuable To Us** | **Very Valuable To Us** | **Extremely Valuable To Us** |
|---|---|---|---|---|---|
| 2.3.1 Reduces CEM modeling /analysis cycle time by 50% by enabling CEM tools to run faster | 2.3.1 | 2.3.1 | 2.3.1 | 2.3.1 | 2.3.1 |
| 2.3.2 Expert system greatly simplifies user inputs required to do sophisticated CEM modeling tasks | 2.3.2 | 2.3.2 | 2.3.2 | 2.3.2 | 2.3.2 |
| 2.3.3 Interactive artificially - intelligent user interface helps user make modeling- design- optimization decisions | 2.3.3 | 2.3.3 | 2.3.3 | 2.3.3 | 2.3.3 |
| 2.3.4 Artificial intelligence makes the system more expert over time | 2.3.4 | 2.3.4 | 2.3.4 | 2.3.4 | 2.3.4 |
| 2.3.5 Can simulate a wide range of environmental electromagnetic effects | 2.3.5 | 2.3.5 | 2.3.5 | 2.3.5 | 2.3.5 |
| 2.3.6 Can be used as a front end to drive a wide variety of AI/EM analysis codes | 2.3.6 | 2.3.6 | 2.3.6 | 2.3.6 | 2.3.6 |
| 2.3.7 Can be used as a front end to drive your existing in-house analytical tools | 2.3.7 | 2.3.7 | 2.3.7 | 2.3.7 | 2.3.7 |
| 2.3.8 Can translate your in-house codes into codes for industry-standard CEM tools | 2.3.8 | 2.3.8 | 2.3.8 | 2.3.8 | 2.3.8 |
| 2.3.9 Can run on your existing or future platforms | 2.3.9 | 2.3.9 | 2.3.9 | 2.3.9 | 2.3.9 |
| 2.3.10 Can run on a wide variety of hardware & software platforms | 2.3.10 | 2.3.10 | 2.3.10 | 2.3.10 | 2.3.10 |
| 2.3.11 Modular architecture makes it easy to add new features and capabilities | 2.3.11 | 2.3.11 | 2.3.11 | 2.3.11 | 2.3.11 |
| 2.3.12 Modular architecture | 2.3.12 | 2.3.12 | 2.3.12 | 2.3.12 | 2.3.12 |

| Attribute | Not At All Valuable To Us | Marginally Valuable To Us | Somewhat Valuable To Us | Very Valuable To Us | Extremely Valuable To Us |
|---|---|---|---|---|---|
| enables integration into enterprise-wide information systems | | | | | |
| 2.3.13 Accurate enough to reduce product redesign requirements significantly | 2.3.13 | 2.3.13 | 2.3.13 | 2.3.13 | 2.3.13 |
| 2.3.14 Accurate enough to certify with 99.5% confidence that a design will comply with key specifications | 2.3.14 | 2.3.14 | 2.3.14 | 2.3.14 | 2.3.14 |
| 2.3.15 Accurate enough to enable testing in real time (via simulation) | 2.3.15 | 2.3.15 | 2.3.15 | 2.3.15 | 2.3.15 |
| 2.3.16 Expert training and consulting assistance available to users 24 hours each day | 2.3.16 | 2.3.16 | 2.3.16 | 2.3.16 | 2.3.16 |
| 2.3.17 Backed by a reputable engineering systems software vendor | 2.3.17 | 2.3.17 | 2.3.17 | 2.3.17 | 2.3.17 |
| 2.3.18 Other desirable attribute 1 (describe) | 2.3.18 | 2.3.18 | 2.3.18 | 2.3.18 | 2.3.18 |
| 2.3.19 Other desirable attribute 2 (describe) | 2.3.19 | 2.3.19 | 2.3.19 | 2.3.19 | 2.3.19 |

2.3.20 Other desirable attribute #1: ______________________________

2.3.21 Other desirable attribute #2: ______________________________

## 3. Your Business's Decision To Purchase An Improved CEM Analysis & Simulation Tool

3.1 How interested is your business in improving its EM analysis and simulation capabilities *(check one)?*

| No Interest | Slight Interest | Some Interest | Strong Interest | Very Strong Interest |
|---|---|---|---|---|
| | | | | |

3.2 If EM analysis and simulation methods were made dramatically easier, faster, and less expensive, how broadly would you use them in your product design processes *(check one)?*

| Would Not Use At All | Use On A Few High-Complexity Projects Only | Use On 20-50% of Projects | Use On More Than 50% of Projects | Use on All Projects |
|---|---|---|---|---|
| | | | | |

3.3 For the "ideal CEM tool" that you have described in Section 2 above, what is the highest acquisition cost at which the tool would be a "no-brainer" for your business to buy and use?
3.3.1 Enter a maximum purchase price at which acquisition of the product would be a "no-brainer" for your business here:
$__________
3.3.2 Enter a maximum number of training hours per user here: __________
3.3.3 Enter the number of people you would want to train here: __________

## 4. Demographic Profile of Your Business Situation

Thank you very much for contributing to our user-needs survey. The following additional questions will help us to place your responses with those from similar users.

4.1 Which of the following best describes your business *(check one)?*
4.1.1 _____Commercial Industry
4.1.2 _____Government/Military
4.1.3 _____University/Academia
4.1.4 _____Aerospace/Defense Contractor
4.1.5 _____Consulting Engineer – Defense
4.1.6 _____Consulting Engineer – Commercial
4.1.7 _____Other (Please specify below)
4.1.8 ____________________________________________________________

4.2 What types of products or technologies do you work on most of the time *(check the one that most closely fits your current assignment)?*
4.2.1 _____Commercial Jet Transport
4.2.2 _____Other Commercial Aviation
4.2.3 _____Automotive
4.2.4 _____Commercial Satellite
4.2.5 _____Telecommunications Equipment
4.2.6 _____Telecommunications Service
4.2.7 _____Radio & TV Equipment
4.2.8 _____Radio & TV Broadcast Services
4.2.9 _____Medical Equipment
4.2.10 _____Consumer Electronics
4.2.11 _____Computer Equipment
4.2.12 _____Electric Power Generation And Transmission Equipment
4.2.13 _____Electric Power Generation And Transmission Service (Utility)
4.2.14 _____Semiconductor
4.2.15 _____Other Aerospace/Defense Programs
4.2.16 _____Other (Please specify below)
4.2.17 ____________________________________________________________

4.3 What department or function do you work in *(check the one that most closely fits your current job assignment)?*
4.3.1 _____Engineering/Product Development
4.3.2 _____Regulatory Compliance
4.3.3 _____Quality
4.3.4 _____Testing
4.3.5 _____Safety
4.3.6 _____Reliability
4.3.7 _____Project Management
4.3.8 _____General Management
4.3.9 _____Other (Please specify below)
4.3.10 ____________________________________________________________

4.4 What is the highest college or university degree that you have received *(check one)?*
4.4.1 _____None
4.4.2 _____B.S.
4.4.3 _____M.S.
4.4.4 _____Ph.D.

4.5 What is your degree in? (Check one)?
4.5.1 _____Electrical Engineering
4.5.2 _____Computer Science
4.5.3 _____Other (Please specify below)
4.5.4 ____________________________________________________

4.6 What best describes your personal role in using CEM tools *(check one)?*
4.6.1 _____Unfamiliar with tools
4.6.2 _____Expert user
4.6.3 _____Generalist user
4.6.4 _____Supervise users
4.6.5 _____Manage a department that includes users
4.6.6 _____Other (Please specify below)
4.6.7 ____________________________________________________

4.7 How many full-time-equivalent people does your business employ to do EM analysis & testing *(check one; include both employees and contractors)?*
4.7.1 _____0 FTEs
4.7.2 _____1 FTE
4.7.3 _____2-5 FTEs
4.7.4 _____6-10 FTEs
4.7.5 _____11-25 FTEs
4.7.6 _____26+ FTEs

4.8 How do the people described above allocate their time in each of the following areas:

| **EM Testing** | **100%** | **75%** | **50%** | **25%** | **0%** |
|---|---|---|---|---|---|
| **EM Analysis** | **0%** | **25%** | **50%** | **75%** | **100%** |
| 4.8.1 Concept Investigation | 4.8.1 | 4.8.1 | 4.8.1 | 4.8.1 | 4.8.1 |
| 4.8.2 Pre-Prototype & Preliminary Design Evaluation | 4.8.2 | 4.8.2 | 4.8.2 | 4.8.2 | 4.8.2 |
| 4.8.3 Finished Prototype Evaluation | 4.8.3 | 4.8.3 | 4.8.3 | 4.8.3 | 4.8.3 |
| 4.8.4 Regulatory Compliance & Certification | 4.8.4 | 4.8.4 | 4.8.4 | 4.8.4 | 4.8.4 |
| 4.8.5 Quality Control in Production Units | 4.8.5 | 4.8.5 | 4.8.5 | 4.8.5 | 4.8.5 |
| 4.8.6 Post-Production Troubleshooting | 4.8.6 | 4.8.6 | 4.8.6 | 4.8.6 | 4.8.6 |
| 4.8.7 Developing New EM Methods | 4.8.7 | 4.8.7 | 4.8.7 | 4.8.7 | 4.8.7 |
| 4.8.8 EM Education & Training | 4.8.8 | 4.8.8 | 4.8.8 | 4.8.8 | 4.8.8 |
| 4.8.9 Other | 4.8.9 | 4.8.9 | 4.8.9 | 4.8.9 | 4.8.9 |

4.9 Which of the following CAD/CAE/CAM packages does your business use widely (check all that apply):
4.9.1 _____AUTOCAD
4.9.2 _____ACAD
4.9.3 _____CATIA
4.9.4 _____CADKey
4.9.5 _____UNICAD
4.9.6 _____SDRC I-DEAS
4.9.7 _____P-CAD (TANGO)
4.9.8 _____PROTEL
4.9.9 _____CAD SOFTWARE (PADS)
4.9.10 _____SCI-CARDS
4.9.11 _____RAYCAL-REDAC (VISUALA)
4.9.12 _____PROENGINEER
4.9.13 _____FUTURENET
4.9.14 _____ORCAD
4.9.15 _____CADRA
4.9.16 _____BRL-CAD
4.9.17 _____Other (Please specify below)
4.9.18 ____________________________________________

4.10 What computer hardware do you use personally *(check all that apply)?*

| | **Use Today** | **Plan to Use Within 2 Years** |
|---|---|---|
| 4.10.1 None | 4.10.1 | 4.10.1 |
| 4.10.2 Win-Intel PC | 4.10.2 | 4.10.2 |
| 4.10.3 Mac | 4.10.3 | 4.10.3 |
| 4.10.4 Sun Workstation | 4.10.4 | 4.10.4 |
| 4.10.5 Silicon Graphics Workstation | 4.10.5 | 4.10.5 |
| 4.10.6 Windows NT Workstation | 4.10.6 | 4.10.6 |
| 4.10.7 Mainframe System | 4.10.7 | 4.10.7 |
| 4.10.8 High-Performance Computing (Paragon etc.) | 4.10.8 | 4.10.8 |
| 4.10.9 Massively Parallel Processors | 4.10.9 | 4.10.9 |
| 4.10.10 Other (please specify below) | 4.10.10 | 4.10.10 |

4.10.11 Other hardware platform: ____________________________________________

4.11 Does your business certify many of its products for export *(check as many as apply)?*
4.11.1 _____NATO countries
4.11.2 _____European Economic Union or European Community
4.11.3 _____Japan
4.11.4 _____Other

## 5. Conclusion & Next Steps

Congratulations, you're done! Please accept our profound thanks for taking the time to contribute your insights.

5.1 Are you willing to participate in follow-up discussions after we have analyzed the results of this survey *(check one)?*
5.1.1 _____Yes
5.1.2 _____No
5.2 If you checked Yes above, please enter the information below. Remember, your responses will be kept confidential!
5.2.1 Your Name: ____________________________
5.2.2 Your E-Mail Address: ____________________________
5.2.3 Your Company Name: ____________________________
5.2.4 Your Voice Phone Number: ____________________________
5.2.5 Your Fax Phone Number: ____________________________

# THE APPLIED COMPUTATIONAL ELECTROMAGNETIC SOCIETY

## ANNOUNCES

# The 13th Annual Review of Progress in Applied Computational Electromagnetics

## March 17-21, 1997

## Naval Postgraduate School, Monterey, California

## Share your knowledge and expertise with your colleagues

The Annual ACES Symposium is an ideal opportunity to participate in a large gathering of EM analysis enthusiasts. The purpose of the Symposium is to bring analysts together to share information and experience about the practical application of EM analysis using computational methods. The symposium offerings include technical presentations, demonstrations, vendor booths and short courses. All aspects of electromagnetic computational analysis are represented. Contact Eric Michielssen for details.

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The ACES Symposium is a highly influential outlet for promoting awareness of recent technical contributions to the advancement of computational electromagnetics. Attendance and professional program paper participation from non-ACES members and from outside North America are encouraged and welcome.

| **Early Registration fees:** | | | |
|---|---|---|---|
| | "ACES" MEMBER | $255. | |
| | NON-MEMBER | $295. | |
| | STUDENT/RETIRED/UNEMPLOYED | $115. | (no proceedings) |
| | STUDENT/RETIRED/UNEMPLOYED | $150. | (includes proceedings) |

**1997 ACES Symposium**
Sponsored by: ACES, NPS, DOE/LLNL, U of KY, U of IL, DOD, SIAM, NCCOSC and AMTA
in cooperation with: The IEEE Antennas and Propagation Society, the IEEE Electromagnetic Compatibility Society and USNC/URSI

# WANTED: NECing HAMS FOR ACES '97

Perry Wheless is seeking authors for a paper session at the Applied Computational Electromagnetics Society (ACES) '97 Symposium on "CEM Applications in Amateur Radio." The first-time offering of this session in 1996 was very successful. You do not have to be an ACES member to submit a paper and/or attend the Symposium. This is an opportunity for hams to combine their work and hobby, and to perpetuate the time-honored ACES tradition of interest in NEC applications to HF/VHF wire antennas. Prospective authors should note that October 25 is in the deadline for summaries (approximately 300 words), and that the full paper does not have to be completed until January. Contact Perry by phone at 205-348-1757 or e-mail at wwheless@ua1vm.ua.edu if you would like to discuss your idea for a paper in advance of submission. Also, I will need to give you some special submission instructions.

Last year, this special session was conducted on Monday evening after a dinner social. If you will be among the HAMZ at ACES, even if you do not submit a paper, give me your e-mail address and I will be sure that you receive an invitation to the 1997 dinner.

More information about ACES membership is available from Dr. Richard W. Adler (a.k.a. Dick, K3CXZ) at e-mail rwa@ibm.net. More details about the conference are available from Dr. Eric Michielssen, Technical Program Chairman for ACES '97, at e-mail michiels@decwa.ece.uiuc.edu. If you need a copy of the Call for Papers, let me know and I will e-mail you a copy.

The ACES annual Symposium is an important forum for the exchange of information and experience among engineers and scientists working with Computational Electromagnetics. Solutions of applied (practical) problems with CEM techniques traditionally have been given high priority in ACES. For a rewarding and memorable experience in a unique atmosphere, you should plan now to be in Monterey, CA, the third week of March! CU there. 73,

Perry, K4CWW

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## An "Interest" Inquiry to NEC Users:

Many NEC users are seasoned CEM veterans, thoroughly trained in the underlying principles. However, it seems that university courses on CEM, particularly the Moment Method, are generally less available to young engineers than they were a few years back.

Our videotape extension learning service (QUEST) has some interest in developing a graduate-credit CEM course offering, possibly starting next semester, but I don't have a good feel for the merit of such a project. I would appreciate comments about the idea from NEC users, both new and old. Please respond either by e-mail to wwheless@ua1vm.ua.edu or telephone at 205-348-1757.

Thanks. Keep those NEC applications coming!

Perry Wheless
Department of Electrical Engineering
University of Alabama
Box 870286
Tuscaloosa, AL 35487-0286

# STUDENT BEST PAPER CONTEST

**This will be for the "Best Paper",**

**submitted for publication in the 1997,**

**13th Annual Review of Progress.**

**(Student must be the presenter**

**on the paper chosen)**

**Submissions will be judged**

**by three (3) members of the BoD.**

**The prizes will consist of:**

**(1) free Annual Review Attendance**

**for the following year;**

**(2) one free short course during**

**the 1997 Annual Review;**

**and**

**(3) $200 cash.**

# THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

## 13TH ANNUAL REVIEW OF PROGRESS
## IN APPLIED COMPUTATIONAL ELECTROMAGNETICS

March 17 - 21, 1997
Naval Postgraduate School
Monterey, CA

## Registration Form

Please print (BLACK INK) (NOTE: CONFERENCE REGISTRATION FEE DOES NOT INCLUDE ACES MEMBERSHIP FEE OR SHORT COURSE FEE)

LAST NAME FIRST NAME MIDDLE INITIAL

COMPANY/ORGANIZATION/UNIVERSITY DEPARTMENT/MAIL STATION

MAILING ADDRESS

CITY PROVINCE/STATE COUNTRY ZIP/POSTAL CODE

TELEPHONE FAX E-MAIL ADDRESS AMATEUR RADIO CALL SIGN

| | BEFORE 3/1/97 | 3/1/96 TO 3/11/97 | AFTER 3/11/97 |
|---|---|---|---|
| ACES MEMBER | ☐ $ 255 | ☐ $ 270 | ☐ $ 285 |
| NON-MEMBER | ☐ $ 295 | ☐ $ 310 | ☐ $ 325 |
| STUDENT/RETIRED/UNEMPLOYED | ☐ $ 115 (no proceedings) | ☐ $ 115 | ☐ $ 115 |
| STUDENT/RETIRED/UNEMPLOYED | ☐ $ 150 (includes proceeding) | ☐ $ 150 | ☐ $ 150 |
| BANQUET ☐ Meat ☐ Fish | ☐ $ 30 | ☐ $ 30 | ☐ $ 30 |

**Short Course information is not available at this time. If you desire Short Course information, please contact Keith Whites. If you plan to attend this conference, and are NOT presenting a paper, please return this form to Richard W. Adler, complete address on call for papers. If you ARE presenting a paper, send this form to: Eric Michielssen, complete address on Call for papers.**

### CREDIT CARD USERS

**IF YOU ARE PAYING BY CREDIT CARD & CARD IS YOUR OWN, FILL OUT THE INFORMATION REQUESTED ABOVE AND SIGN YOUR NAME BELOW *. IF THE CARD YOU ARE USING IS NOT YOUR CARD, FILL OUT THE INFORMATION ABOVE, AND HAVE THE CARD HOLDER (1) PRINT AND SIGN HIS OR HER NAME BELOW, AND (2) ENTER HIS OR HER COMPLETE ADDRESS BELOW. THIS IS MANDATORY IF YOU USE CREDIT CARDS.**

Non-USA participants: Prices are in U.S. dollars. All currencies must be converted to U.S. dollars payable by banks with U.S. affiliates. (1) **Bank Checks**, if (a) drawn on a U.S. Bank, (b) have U.S. bank address, (c) contain series of (9) digit mandatory routing numbers; (2) **Traveler's Checks** (in U.S. $$); **(3) International Money Order** drawn in U.S. funds, payable in U.S.; (4) **Credit Cards:** Visa, MasterCard, Discover and AmEx.

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**Method of payment**: ☐ A bank check for the total amount is enclosed.(1)
☐ Traveler's checks for the total amount are enclosed.(2)
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☐ Charge to: ☐ MasterCard ☐ Visa ☐ Discover ☐ AmEx.(4) .

Card No. ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ Exp. Mo. ____ Yr. ____

PRINT NAME SIGN NAME

ADDRESS

ADDRESS

**17-21 MARCH 1997**

**** (WITHIN WALKING DISTANCE OF NPS)**

**FOR ALL MOTELS IN AREA, WEEKEND RATES MAY BE HIGHER. PLEASE CHECK.**

**(Most of these motels have been recommended in the past, no rates have been confirmed yet!)**

**FIRESIDE LODGE (**)** (1 star)
1131 10th St. Monterey, CA 93940
(408) 373-4172

**STAGECOACH MOTEL ( ** )** (1 Star)
1111 10th St. Monterey, CA 93940
(408) 373-3632

**HYATT HOTEL & RESORT (**)** (4 Star)
1 Old Golf Course Rd. Monterey, CA 93940
(408) 372-1234

**MONTEREY BAY LODGE ( ** )**
55 Camino Aguajito, Monterey, CA 93940
(408) 372-8057

**HOLIDAY INN ( ** )** (3 Star)
1000 Aguajito Rd. Monterey, CA 93940
(408) 373-6141

**SUPER 8 MOTEL** (2 Star)
2050 Fremont St. Monterey, CA. 93940
(408) 373-3081

**EMBASSY SUITES, HOTEL & CONF. CENTER**
1441 Canyon Del Rey, Seaside, CA 93955
(408) 393-1115, Fax: (408) 393-1113
For reservations call 1-800-EMBASSY

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## IMPORTANT INFORMATION FOR ACES ATTENDEES, PLEASE READ.

**Hotel room tax exemption requires all of the following documents: (1) Travel Orders, (2) Payment by government issuedAMEXcard; (3) Govt./Military identification. Regarding Govt. rates: prevailing perdiem lodging rate at time of arrival will be honored.**

**When you book a room mention that you are attending the "ACES" Conference, and ask for either Government, or Conference rates.**

**There is NO Conference PARKING at the Naval Postgraduate School or on nearby streets, so we advise you to book a room within walking distance, or plan to use a taxi.**

**Third Street Gate is the closest gate to the Conference Registration location. Gates open at 0600 (AM) and close at 1800 (6 PM) daily. After 1800 hours, the Main Gate (between Ninth and Tenth Streets), is the only gate open.**

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## AIRLINE INFORMATION

**The following airlines make connections from Los Angeles and San Francisco, CA. to Monterey, CA: American, United, Delta/Sky West, and US Air.**

**There is no connection directly from San Jose, CA to Monterey, CA. You can fly to San Jose, but then ground transportation must be used. Monterey-Salinas-Airbus serves San Francisco International (SFO) and San Jose International (SJC). There are five departures daily from Monterey and Salinas, arriving at both SFO & SJC, appx. (2-4) hours later. There is also the same departures from SFO & SJC. For information and an updated schedule, phone (408) 442-2877 - (800) 291-2877.**

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## THINGS TO DO AND SEE IN THE MONTEREY BAY AREA

**There are many activities for children and adults not attending the Conference. The colorful blue Monterey Bay is a vision of historic Monterey, rich with natural beauty and many attractions from Fisherman's Wharf, (be sure to try the seafood cocktails), to Cannery Row, the Monterey Adobes and city parks, the Monterey Bay Aquarium, Maritime Museum of Monterey, and Pacific Grove Museum of Natural History. The "Artichoke Capital of the World" is only 15 miles from Monterey, in Castroville. Other things to do include: driving the 17-Mile Drive in Pebble Beach, Whale watching, bicycle riding, roller blading, surfing, taking a stroll on the white sandy beach in Carmel, a visit to Mission San Carlos Borromeo Del Rio Carmelo, in Carmel, etc. The Monterey Peninsula has 20 Golf Courses. Carmel has many Art Galleries. For more information, call the Monterey Peninsula Chamber of Commerce, Visitors and Convention Bureau at (408) 649-1770.**

# CALL FOR PAPERS

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

## COMPUTATIONAL ELECTROMAGNETICS AND HIGH-PERFORMANCE COMPUTING

The Applied Computational Electromagnetics Society is pleased to announce the publication of a 1998 Special Issue of the *ACES Journal on Computational Electromagnetics and High-Performance Computing*. The primary objective of this special issue is to present a survey of the present state of the art of high-performance computing applied to computational electromagnetics.

Papers submitted should concentrate on computational aspects of electromagnetics: these include problem sizes; operation counts; parallel algorithms; and hardware aspects (although the last should avoid great technicalities). High-performance computing includes supercomputing, high-performance workstations and multi-processor networks. Complete simulation packages that consider the integration of mesh generation, electromagnetic solvers, and post-processing are especially relevant. Algorithms developments (such as the Fast Multipole Method) are only appropriate in this context if specifically related to high speed computation. Similarly, papers dealing only with high speed computation, without a CEM application, will be of limited suitability.

### SUGGESTED TOPICS

- Supercomputers
- Multi-processor networks
- Optimization methods
- High-performance workstations
- Performance modelling
- Adaptive methods
- Parallel environments - especially portable ones such as PVM
- Computational Electromagnetics Applications including: Moment Method/Integral and Integro-Differential Equation methods; Finite Element method; Finite Difference Time Domain method; Transmission Line Modeling method; Asymptotic methods (GTD, UTD, etc); other methods such as MMP; Linear Algebra techniques for these methods where appropriate.

**DEADLINE FOR PAPERS IS JULY 1, 1997**

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