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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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2005 FINANCIAL REPORT

ASSETS

BANK ACCOUNTS	**1 JAN 2005**	**31 DEC 2005**
Main Checking	13,772	20,380
Oxford Checking	24,021	33,818
Editor Checking	3,337	0
Secretary Checking	4,918	0
Savings	111	111
Editor Savings	26	0
Secretary Savings	25	0
High Rate Savings	11,089	11,213
Credit Card	10,702	14,037
Transfer	4,767	4,796
CD 16406	14,812	15,094
CD 17227	14,437	14,700
CD 17228	14,700	0
CD 17673	14,625	14,967
TOTAL ASSETS:	$ 131,342	$ 129,116
LIABILITIES:	0	0
NET WORTH:	$ 131,342	$ 129,116

INCOME AND EXPENSES

INCOME

Conference	67,892
Short Courses	1,525
Publications	699
Membership	12,529
Website	500
Interest	1,182
Miscellaneous	2,024
TOTAL INCOME	$ 86,351

EXPENSES

Conference	55,311
Short Courses	838
Publications	12,537
Services (Legal, Taxes, Secretarial)	4,294
Postage/Communications	5,245
Bank/Credit Card Fees	1,344
Website	8,228
Supplies and Misc.	785
TOTAL EXPENSES	$ 88,582

2004 NET PROFIT (LOSS): $ (2,231)

Notes:

1. The proceeds of the 2005 conference held in Honolulu, Hawaii were received in March 2006, but are included in the above report to more accurately reflect the 2005 financial status of the society.

2. The 2004 net operating profit was $14,640 (including the 2004 conference profit), while in 2005 the society had a net operating loss (including the 2005 conference profit; see Note 1 above) of $2,231.

3. The 2005 year-end net worth of ACES was $129,116, representing a decrease of 1.7% compared to the 2004 year-end net worth.

Allen Glisson
Treasurer

Satisficing in Computational Electromagnetics

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Introduction

Nevil Shute said "An engineer is someone who can do for ten shillings what any fool can do for a pound" [1]. This doesn't only imply ingenuity, it implies being able to perform trade-offs. Where these trade-offs are not adequately performed leading to a product with a better specification than needed, we often refer to the system as "Over-engineered". Engineering can be said to boil down to solving practical problems within the constraints specified by the problem itself, including factors such as time constraints and limitations on costs. Of course, in Nevil Shute's time, finite element analysis and computational fluid dynamics were still some years away. However, they are commonplace in mechanical systems design these days. Most engineering calculations were done with slide rules, with the inherent approximations and inaccuracies, because the costs in time in doing precision arithmetic were prohibitive. Yet, this was generally good enough.

Considering another example which suggests that the optimum engineering solution is not the most appropriate systems solution: ' "We work to a spreadsheet where there is a bottom line on what we had to meet," says Brooks, whose iRobot company worked with Hasbro on the interactive doll My Real Baby. The goal was to make the doll as lifelike as possible, but if a component cost a penny too much the bean-counters vetoed it-even if it would have made a big difference to performance. "This almost made some of the engineers cry," Brooks says.'[2]

What we do, pretty much every day, is to set up models or measurements that are good enough, trying to resist the urge to over-engineer. This is captured by the concept of "satisficing" which starts to give a framework for rigor in deciding on these trade-offs.

So, what is satisficing? When searching for a solution to a problem there is an expectation that the solution will be the optimum solution. Sometimes this is not practical, and we must be satisfied with "good enough": something that meets the minimum requirements but perhaps not much more. Satisficing embodies this idea, and carries with it the implication that it is no bad thing to meet the minimum need and not necessarily the optimum solution to all requirements. Optimality is not always mandated. A concept which is familiar to most people is that cost increases with search space: if you have a short time to shop you may well be satisfied with a purchase quality that could be improved on if more time was available. Satisficing behavior would be to stop at the first "good enough" product, where as optimizing behavior would be to shop until all the time was expended, except that needed to go back and purchase the best product. One hears of people "going beyond the call of duty". The 'call of duty' would have been good enough but this person went beyond that? Clearly one's duty in this case is less than the optimal behavior [3].

An optimizing strategy can, ironically, be suboptimal: improving the performance of a product may delay its roll-out However, time to market may well make the difference between your product getting market share and someone else's getting market share, i.e. missing first mover advantage. Whereas a satisficing (good enough) strategy would produce much better returns overall.

In chapter 15 of [4], in which the term "satisficing" was coined, it is argued that a complex algorithm need not exist to achieve satisficing behavior. This article aims to look at satisficing from the standpoint of CEM and suggest a relatively simple strategy for realizing a satisficing approach to simulations, which encourages all parties involved in the modeling to understand the assumptions, constraints and limitations involved in getting it “good enough”

In EMC Veritas.

How can satisficing be used in EMC work? Firstly, there are a number of areas where time/cost tradeoffs occur, and we must decide how to meet those constraints. For example, when considering product design we must understand how the product, whatever it may be, will behave in susceptibility and emissions terms, and we must therefore have a good enough understanding of this to allow our design to meet the various national or international directives. We could optimize our simulations for best attainable accuracy, or we could just make them sufficiently accurate for the task in hand. Here we run into semantics: what do we mean by sufficiently accurate? “Truth? What is that?” is a question that goes back at least two millennia!

Stirling [5] describes how searching for an optimum value is a global search, requiring knowledge of the whole space of possibilities. This is described as "substantive rationality", and given a tractable mathematical model of the system being explored, the optimum is provably the best. He goes on to say that this is not the only way to decide what is acceptable. In "procedural rationality" an algorithmic approach to finding a solution is used. Thus, rather than analysis, search is used. For example, one may use hill climbing, the simplex method, simulated annealing, genetic algorithms, or particle swarm optimization to obtain an acceptable solution. Given that all these methods involve exploration of the solution space to find an acceptable solution, rather than direct derivation of the solution, it is possible, and for complex systems even likely, that a better solution can be found. However, since the search process justifies the choice in terms of meeting the criteria, the resulting solution is still acceptable.

There are systems where it is not possible to derive a tractable equation for the system to be analyzed, but a solution can be recognized relatively easily. This is the case where simulations or experiments are used to determine the acceptability of a system's configuration. Usually there is some high dimensionality (many degrees of freedom) in the problem domain that would make derivation impossible. Given the number of wires in the wiring loom of a vehicle, for example, the number of possible layouts is enormous. Even in something as apparently simple as modeling twisted pair cabling, performing an analytical assessment of the costs of materials and technical performance for something with an elliptical cross section is nontrivial.

Simulation is standard practice in many fields of engineering. In electromagnetics it is clearly cheaper to compute results than to actually cut metal and try things out and can provide a better insight than possible with measurements alone. But accepting this state of affairs begs the question: are the simulations themselves satisfactory? How good do they need to be, and how much can we reduce the computational time and thus the cost in order to get a satisfactory answer?

How to Satisfice

The need for satisficing behavior has been argued, but the above discussion does not suggest how to apply this. In contrast there is much information about how to apply optimization strategies. So, the following is presented in order to partially redress this imbalance.

1. Consider what the goals of the activity (experiment, simulation) are. A reverberation chamber problem may be to "determine the working volume and stirring ratios within a given chamber for a specified stirrer".

2. Determine the range of parameters and associated collection of values that must be met for those goals to be satisfied. This is akin to determining the region in which solutions lie when doing linear programming. An example might be:

- What simulation method is going to be used, or what range of techniques are available to use (e.g. a member of the set {TLM, BEM, MOM, FDTD})?
- How many computers are there on which we may simultaneously, or in parallel, run simulations?
- What is the available memory?
- What time is available to undertake the simulations? This is, of course a function of other aspects of the model – in the reverberation chamber example this may be a function of modeled time, stirrer positions and frequency resolution
- What accuracy is required of the model? For example how coarse can we accept stepped angular surfaces, what details can be excluded, how accurately is the modeling of material properties required.
- Are there a number of different geometries required for the system? For example, how many stirrer positions are required in the simulations and experiments?

Applying a satisficing approach to the reverberation chamber modeling problem, the criteria above lead us to decide that we will use TLM (we have the software), on one computer (we only have a commercial license for the one machine), that machine has only 1GB of memory, we can only really afford one day for each geometry because we have several to do, and these constraints are the dominant parameters which determine the other parameters. This gives a rational basis for how we proceeded, but other researchers, with different facilities, would proceed differently. In such a case they would be able to supply critique (validation) of our results (how things perform with more or less memory, whether other simulation techniques support this, etc.) We also decided that the level of agreement we were prepared to accept was "fair" because of the simplifications imposed by the above constraints. This term was made numeric using the Feature Selective Validation (FSV) method. Thus, we also established what we meant by satisfactory agreement, in a form which is reproducible and can be communicated to all parties involved.

3. Use "Five Whys" to explore these reasons in depth. "Five Whys" is the practice of mining into actual reasons for a decision by iterating "Why?" about 5 times.

4. Iteratively create models and dry-run them to see if they meet the constraints, on a "Go"/"No Go" basis before proceeding with the actual simulation. Effectively asking whether the constraints have been met or whether the solution is 'over engineered'.

Where is the satisficing activity in this? It is actually in the setting of the criteria and in the "Go"/"No Go" decision. This is the simple system used by Simon [4] in his organism model. An organism requiring food (and possibly water, and other necessities) explores an otherwise featureless landscape, using energy from the food to traverse the space. The food is randomly distributed through the space in random sized heaps, and it finds these visually provided they are near enough to the organism. It sleeps if sated. Simon is able to show that without optimization, the visual range of the organism and its ability to store the energy are the main constraints on its survival, that it has a high probability of survival for reasonable values of these constrains, and that with low energy storage the resource must be plentiful. He gives the example of the abundance of oxygen and the continual need to breathe. Perhaps this accept/reject non-optimizing strategy seems too simple to work. However, Simon shows that meeting the criteria satisfices the need of a simple organism to survive, which is the acid test. In chapter 14 of the same work, Simon explains how this "Go"/"No Go" may be a dynamic function, dependent on information gathered during exploration. For example, if solutions seem to be rare, it may be pragmatic to accept what is available. However, if there are many solutions evident, one may be more discerning.

Discussion

Trading off variables to achieve a workable solution has been a mainstay of engineering practice, so in that sense "satisficing" is nothing new. Also, in the sense that the term has been around since about 1957, it is not itself new. However, with the emphasis in the recent past being on optimization, satisficing is worth considering more closely, principally because of its inherent contribution to cost savings whilst meeting the real constraints. This would seem to tie in with Lean Engineering practice, and thinking tools from the Theory of Constraints [6]. Having a word for this activity aids in its formalization. Formalization, in turn, enables people to discuss this implicit part of engineering practice, making assumptions and decisions explicit, and available to be challenged, re-evaluated, and shared more freely and objectively. An optimum solution may be the result of the search for a sastisficing solution, but the search for an optimum solution would probably reject one that is actually ‘good enough’.

References

[1] Nevil Shute, "Slide Rule: The Autobiography of an Engineer" William Heinemann, London. 1954

[2] Duncan Graham-Rowe, Ben Crystall, Graham Lawton, “Jobs for the bots”, New Scientist, 10 February 2001, pp26-35

[3] Michael Byron “Satisficing and Maximizing: Moral Theorists on Practical Reason” Cambridge University Press 2004

[4] Herbert A..Simon, “Models of man : social and rational : mathematical essays on rational human behavior in a social setting” Chapman & Hall, 1957

[5] Wynn C Stirling “Satisficing Games and Decision Making (with applications to Engineering and Computer Science)” Cambridge University Press 2003

[6] Eliyahu M. Goldratt, Jeff Cox, “The Goal”, North River Press; 3rd edition (July 2004)

Compact Hybrid Dipole-Loop Antenna for the 1.8-2.0 MHz (160m) Band with Full HF Tunability

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Abstract— **This paper describes a novel approach to successful emulation of half-wave dipole performance on the 160-meter amateur radio band (1.8 - 2.0 MHz) with a hybrid wire antenna comprising a dipole part and a loop part, requiring a real estate length component of only 140 feet (42.7m) for deployment. Further, via a switching circuit near the transmitter, the loop and dipole can be routed to separate antenna tuning units (e.g., two identical Nye Viking Model MB-VA ATUs) and individually tuned over all eight amateur bands between 3.5 and 30 MHz.**

I. INTRODUCTION

This article reports a novel solution to the practical need for an effective communications antenna for the 1.8-2.0 MHz (160m) amateur radio band subject to a restricted available land area. Atmospheric noise on the 160m band drops dramatically in the late fall, and 160m becomes a popular and impressive radio communications resource (typically) from early November through mid- to late-April in North America. A resonant full half-wave dipole for 160m is about 250 feet (76.2m) long and, in this case, the longest dimension of the available land was along a line due North-South and with pine tree supports available that are separated by approximately 144 feet (43.9m).

For the Winter 2004 operating season, an experimental trial was conducted with a conventional half-square configuration. Namely, a 140 foot (42.7m) horizontal wire was supported between the available supporting trees at the N-S property line at a height of 50 feet (13.7m) and center-fed with open wire transmission line of characteristic impedance 600Ω. At both the North and South ends, the antenna wire was extended vertically down to a height of about 3 feet (1m) above ground. This trial configuration exhibited three significant shortcomings: (a) it was found that most man-made electrical noise in this frequency range is vertically polarized and, together with vertically-polarized local AM broadcasting, cumulatively produced objectionable interference on receive, (b) extensive operating experience indicated that the antenna was performing, in an overall sense, at a level approximately 6 dB below that normally associated with a horizontal half-wave dipole at height 50 feet (15.2m), and (c) wiring and electronics in residences in close proximity exhibited a greater susceptibility to vertical versus horizational transmit polarization, which was becoming a significant factor with the vertical end wires as described above.

A replacement 160m antenna with better performance was sought. For detailed analysis, numerical modeling with EZNEC version 4.0 [1] was applied throughout this engineering study. For all EZNEC results reported here, real/high accuracy ground was selected with $\sigma = 3$ mS/m and $\epsilon_r = 12$, typical of west central Alabama soil conditions. Also, "copper" wire loss was selected, so the results here include conductor loss.

II. HYBRID DESCRIPTION

Before the Winter 2005 operating season began, a new center-fed 174 foot (53m) horizontal dipole, tunable 3.5-30 MHz with a Nye Viking MB-VA ATU, was installed between the North end tree support and a third tree some 180 feet (54.9m) distant on a bearing 37° West of South. The dipole is center fed with 600Ω ladder line, has end support heights of approximately 45 feet (13.7m), and notably uses the same overall North-South property length of 43.9m as above; the Southwestern end dipole support is a third tree at the South property line and displaced about 105 feet (32m) West of the rear N-S property line.

Also in the interim a triangular loop was installed. The loop feed point is at a height of just nine feet (2.7m) above ground, just outside the radio room's eastern wall. From the feed point, the loop first has a leg approximately 90 feet (27.4m) long to a point at sixty-five feet (19.8m) high on the South end support tree, then proceeding approximately 140 feet (42.7m) to a point forty feet (12.2m) high on the North end support, then continuing a length approximately seventy-two feet (22m) back to the feed point. The geometry details of the loop and dipole described above can be seen in Figures 1 and 2.

Both antennas are fed with 600Ω ladder line. There is a short length, about eleven feet (3.4m) between the Nye Viking MB-VA balanced line antenna terminals and an outside box containing eight SPDT blade switches, which allows the antennas to be separated into separate loop and dipole antennas fed by two separate ATUs, and also allows the four wires comprising the two ladder lines to be grounding during periods of nearby lightning activity. More details on the switching box are given later, and suffice it to note that this represents the common feed point for the 160m antenna for analysis purposes. Parenthetically, the MB-VA circuit is a balun followed by a traditional tee network with one variable inductor and two variable capacitors.

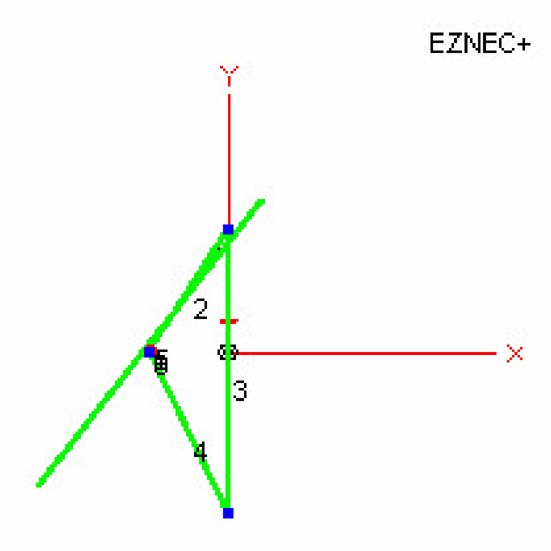


Figure 1. Dipole and loop antennas, top view down the z axis; +y is North.

Note in Figure 2 below that the dipole has a thirty-three foot (10.1m) ladder line section connecting its center feed point to the common feed at the switch box. This appears as a wire (#5) and not a two-wire structure because the two conductors of the ladder line are shorted together by the switch box and fed as a single wire comprising one side of the hybrid antenna (that is, connected to one wire of the ladder line coming from the ATU balanced line terminals).

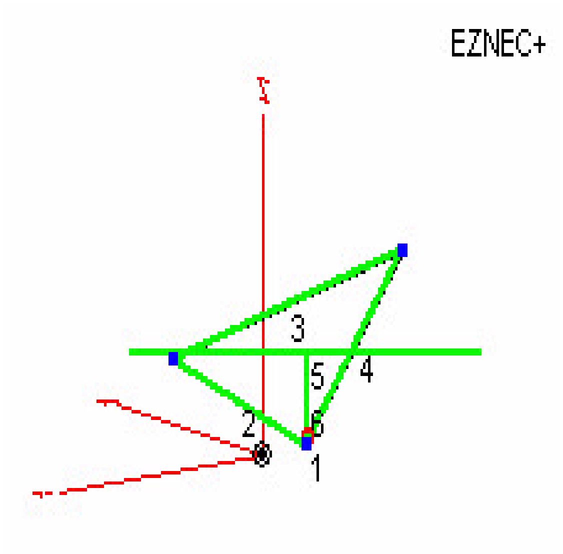


Figure 2. Dipole and loop antennas, oblique view.

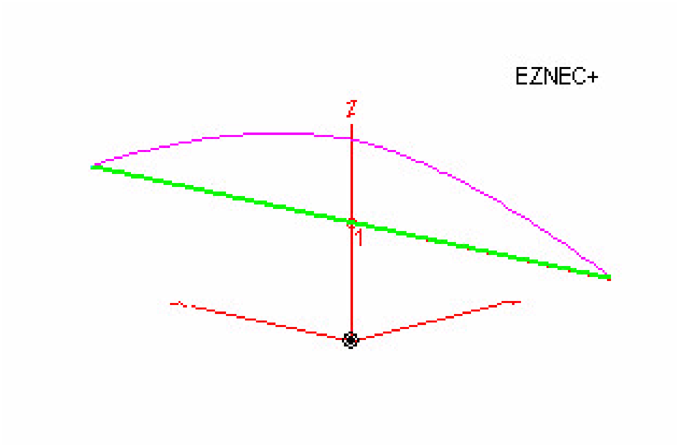


Figure 3. Comparison 160m half-wave dipole at 40 feet (12.2m) height, with current distribution.

III. 160M HYBRID PERFORMANCE

In contrast to the dipole side of the hybrid configuration, which has the ladder line wires shorted to effectively give a single-wire feed at the dipole center in “Marconi" manner, as described above, the loop side of the hybrid is different. Namely, one side of the loop feed point is left open. The remaining ladder line wire from the ATU is connected to the side of the loop feed point that goes to the southern end support. The side of the loop feed point that is created by the return of the loop from the northern end support is left open. Therefore, this “half” of the composite hybrid antenna is the full length of the triangular loop wire, slightly more than three hundred feet (about 93m). An experiment was done with shorting the loop ladder line wires together to give a single wire feed to the loop similar to that used with the dipole, but it was found that the resulting impedance was not tunable with the MB-VA ATU. In the configuration described above, the hybrid antenna is easily tuned to 1:1 SWR over the entire 1.8 - 2.0 MHz band.

The essence of the hybrid’s performance at 160m, which was quite satisfactory to impressive in all aspects, may be presented succinctly. Qualitatively, the antenna garnered signal reports throughout the Winter 2005 prime operating season fully equivalent to other nearby stations running comparable power into full half-wave dipoles at heights of 40-65 feet (12.2 - 19.8m), inverted L’s and Vees. Only after several months of on-air operating experience was gathered was an EZNEC comparison to a full-sized horizontal dipole performed. The analysis indicates that a full-sized horizontal dipole is at a disadvantage to the hybrid at heights below 40 feet (12.2m) but has an increasing advantage with height above that level. It is interesting to note that the hybrid geometry and wire lengths are quite different from a regular dipole, but the average height of the composite hybrid configuration is itself on the order of 40 feet.

Figure 5 shows an East-West elevation plot of the hybrid, with the full-sized dipole at 40 feet overlayed. In the plot, East is to the right and West is to the left. The maximum gains for the two antennas are virtually identical and, as can be seen in the figure, the patterns are very similar. Figure 6 is the corresponding result for an elevation plot on a North-South line, with North to the right. Again, the full dipole and hybrid have virtually identical maximum gain, but in this case the hybrid has a perceptible gain advantage at intermediate elevation angles.

It is noteworthy that the hybrid exhibited a high degree of immunity to incoming vertically-polarized noise. Local AM broadcast and power line noise interference were no longer an issue, as they were with the predecessor half-square antenna.

IV. HF SPECTRUM FLEXIBILITY

It was noted earlier that there is a switch box in the system to allow combining the loop and dipole into a hybrid antenna, fed through one ATU, or separating the dipole and loop into separate transmitter connections through two separate ATUs. Figure 4 is schematic depiction of the switching circuit:

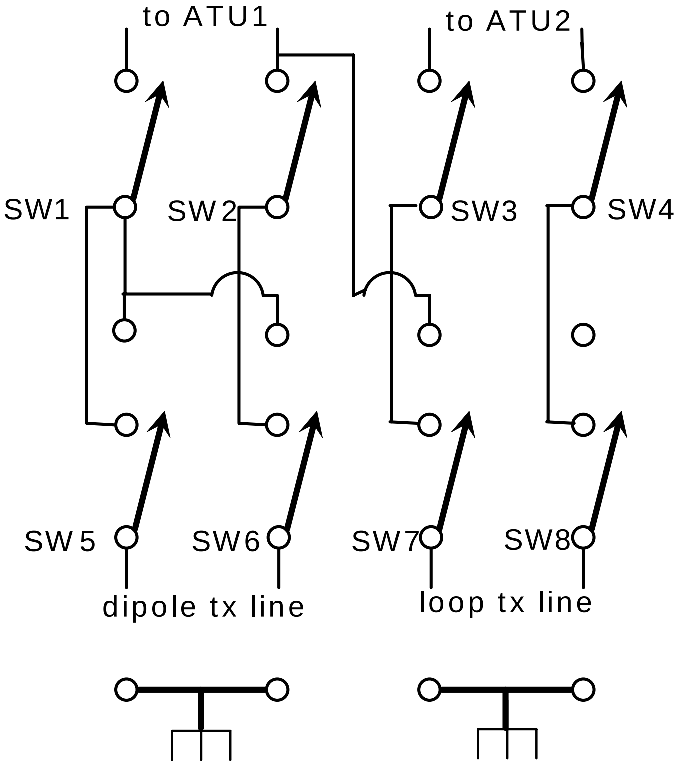


Figure 4. Antenna switch box.

All switches are SPDT, knife blade type. In normal operation, switches SW5 - SW8 are in the up position, as shown. These four switches are connected down to ground the ladder lines for lightning protection. When the four switches SW1 - SW4 are in the up position, as shown, the dipole and loop elements are connected through to separate ATUs 1 and 2. For hybrid operation, the three switches SW2 - SW4 are moved to the down position. One sees that downward movement of switch SW4 creates the desired open circuit on the return line from the triangular loop antenna. Simultaneously, downward movement of SW3 connects the “hot” leg of the loop over to ATU1, while downward connection of SW2 causes the two conductors of the dipole ladder line to be shorted together and connected as the other side of the hybrid antenna feed out of the switch box.

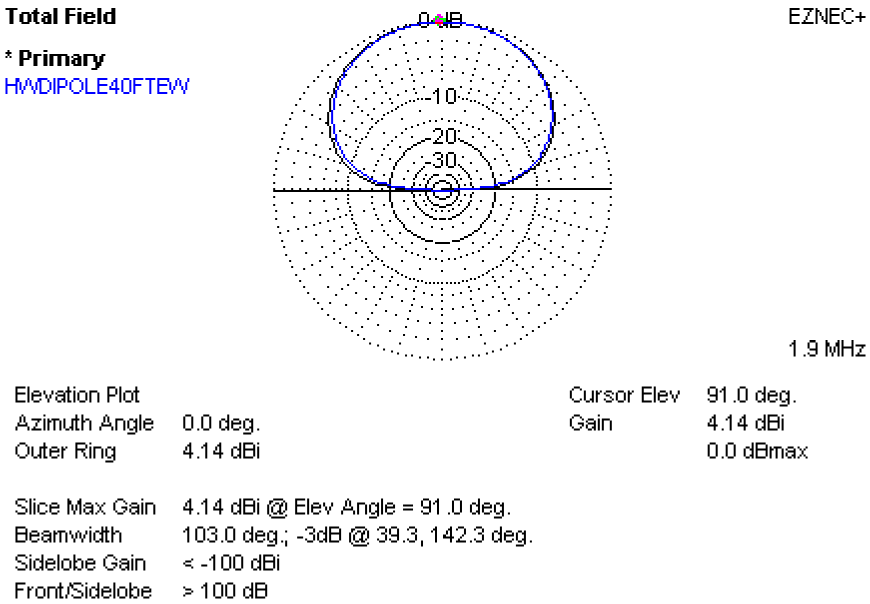
Because the two wire element antennas provide three possible operational modes through different switch selections and all three possibilities are tunable to 1:1 SWR on all the HF ham bands, a variety of radiation pattern possibilities are available to the radio operator. To illustrate, sample azimuth plots at elevation angle 30° have been prepared with EZNEC. For clarity, the three antenna possibilities are given in individual plots, where the pertinent data/quantitative results can be seen clearly. In these plots, North is the positive vertical axis and East is to the right (the positive horizontal axis). Figures 7 through 9 are for 7.3 MHz, at the upper end of the popular medium-range 40m band, and Figures 10 through 12 are the corresponding plots at operating frequency 18.1 MHz (the so-called 17m band). Elevation angle 30° was selected as a medium-distance single hop propagation path compromise between the longer paths associated with lower elevation angles on the order of 10° and more regional links associated with elevation angles on the order of $60 - 70°$.

Note that the respective maximum gain values for the dipole, loop, and hybrid at 7.3 MHz from Figures 7 - 9 are 8.46 dBi @ azimuth angle 143°, 5.97 dBi @ azimuth angle 330°, and 5.96 dBi @ azimuth angle 333°. The qualitative pattern shape differents are best appreciated by visual inspection. At 18.1 MHz, for comparison, the maximum gain numbers are 2.24 dBi @ azimuth angle 21° for the dipole, 4.08 dBi @ azimuth angle 272° for the loop, and 6.46 dBi @ azimuth angle 39° for the hybrid.

V. CONCLUDING REMARKS

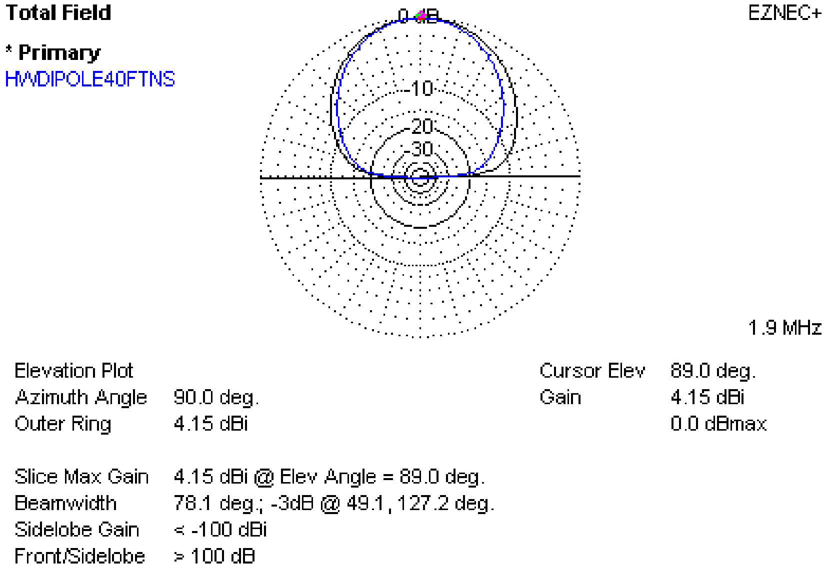
A specific case study is reported here, and the resulting wire antenna configuration is not intended to be a general (160m) low-frequency solution that will fit many potential users. However, it does serve well to illustrate the benefits of unconventional thinking applied to wire antenna needs in the HF radio spectrum.

The straightforward deployment of a horizontal dipole of length 250 feet (76.2m) at a height of 60 feet (18.3m) and fed with low-loss ladder line is clearly the most simple and a highly desirable antenna implementation for routine 160m operation (conceding that the standard of excellence in a transmitting antenna for this band is a vertical radiator at least a quarter-wave tall and accompanied by a full, AM broadcast band quality ground radial system, but at the same time recognizing that such a deployment is beyond the means



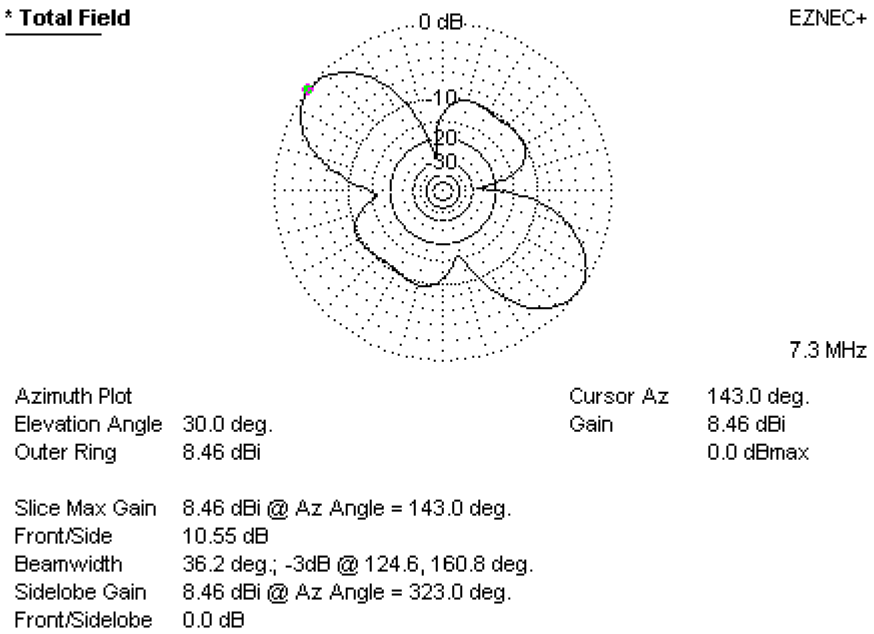
```
Total Field                                              EZNEC+

* Primary
HWDIPOLE40FTEW

                                                         1.9 MHz

Elevation Plot                                  Cursor Elev    91.0 deg.
Azimuth Angle      0.0 deg.                     Gain           4.14 dBi
Outer Ring         4.14 dBi                                    0.0 dBmax

Slice Max Gain     4.14 dBi @ Elev Angle = 91.0 deg.
Beamwidth          103.0 deg.; -3dB @ 39.3, 142.3 deg.
Sidelobe Gain      < -100 dBi
Front/Sidelobe     > 100 dB
```

Figure 5. 160m hybrid vs dipole at 40 feet, E-W elevation plot.



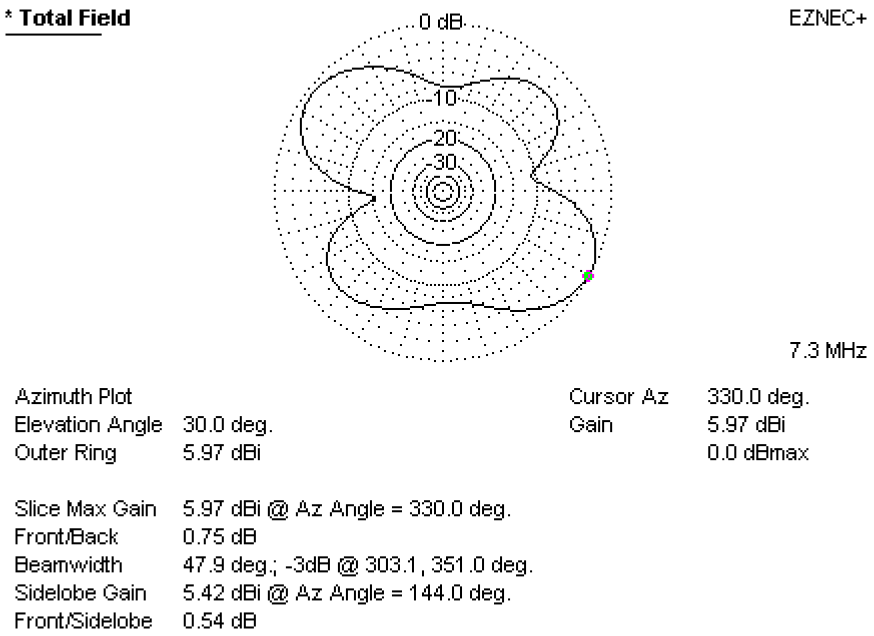
```
Total Field                                              EZNEC+

* Primary
HWDIPOLE40FTNS

                                                         1.9 MHz

Elevation Plot                                  Cursor Elev    89.0 deg.
Azimuth Angle      90.0 deg.                    Gain           4.15 dBi
Outer Ring         4.15 dBi                                    0.0 dBmax

Slice Max Gain     4.15 dBi @ Elev Angle = 89.0 deg.
Beamwidth          78.1 deg.; -3dB @ 49.1, 127.2 deg.
Sidelobe Gain      < -100 dBi
Front/Sidelobe     > 100 dB
```

Figure 6. 160m hybrid vs dipole at 40 feet, N-S elevation plot.



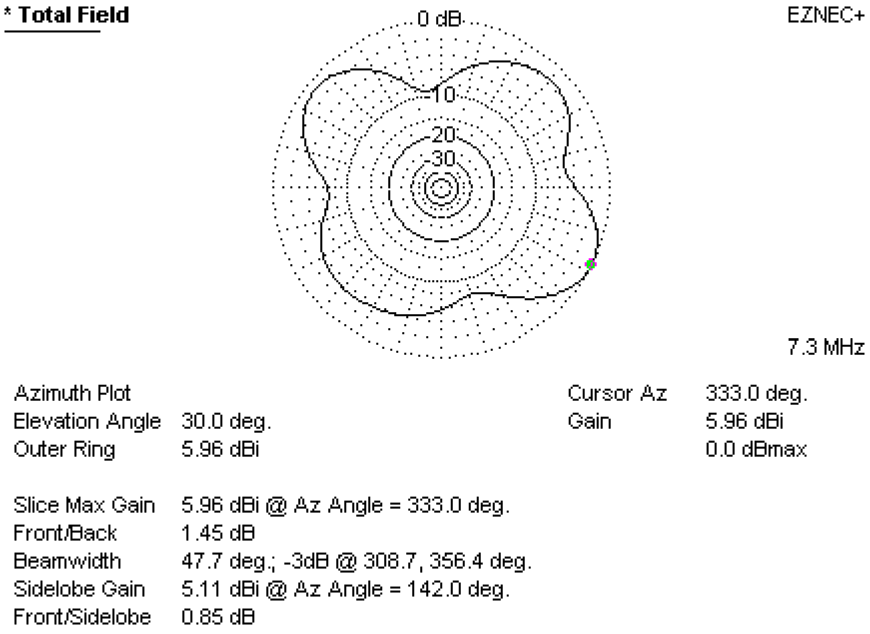
```
Azimuth Plot                                          Cursor Az    143.0 deg.
Elevation Angle   30.0 deg.                           Gain         8.46 dBi
Outer Ring        8.46 dBi                                         0.0 dBmax

Slice Max Gain    8.46 dBi @ Az Angle = 143.0 deg.
Front/Side        10.55 dB
Beamwidth         36.2 deg.; -3dB @ 124.6, 160.8 deg.
Sidelobe Gain     8.46 dBi @ Az Angle = 323.0 deg.
Front/Sidelobe    0.0 dB
```

Figure 7. Dipole element azimuth plot at 7.3 MHz.



```
Azimuth Plot                                          Cursor Az    330.0 deg.
Elevation Angle   30.0 deg.                           Gain         5.97 dBi
Outer Ring        5.97 dBi                                         0.0 dBmax

Slice Max Gain    5.97 dBi @ Az Angle = 330.0 deg.
Front/Back        0.75 dB
Beamwidth         47.9 deg.; -3dB @ 303.1, 351.0 deg.
Sidelobe Gain     5.42 dBi @ Az Angle = 144.0 deg.
Front/Sidelobe    0.54 dB
```

Figure 8. Loop element azimuth plot at 7.3 MHz.

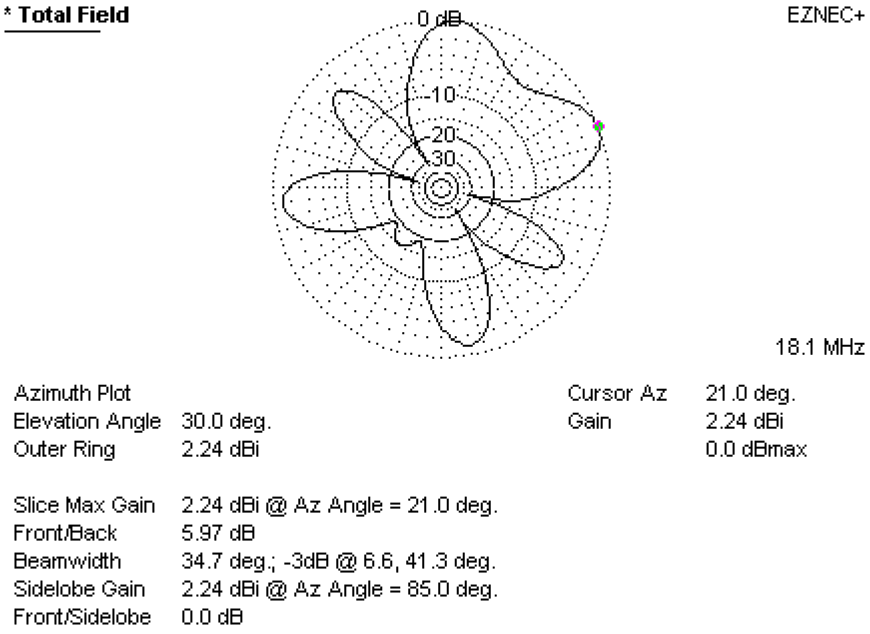


Azimuth Plot
Elevation Angle 30.0 deg.
Outer Ring 5.96 dBi

Cursor Az 333.0 deg.
Gain 5.96 dBi
0.0 dBmax

Slice Max Gain 5.96 dBi @ Az Angle = 333.0 deg.
Front/Back 1.45 dB
Beamwidth 47.7 deg.; -3dB @ 308.7, 356.4 deg.
Sidelobe Gain 5.11 dBi @ Az Angle = 142.0 deg.
Front/Sidelobe 0.85 dB

Figure 9. Hybrid antenna azimuth plot at 7.3 MHz.

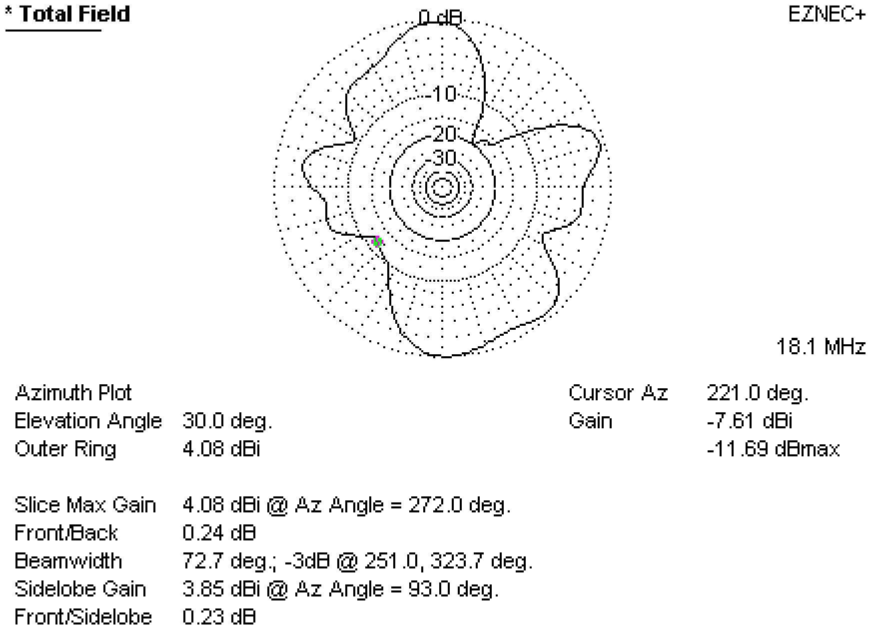


Azimuth Plot
Elevation Angle 30.0 deg.
Outer Ring 2.24 dBi

Cursor Az 21.0 deg.
Gain 2.24 dBi
0.0 dBmax

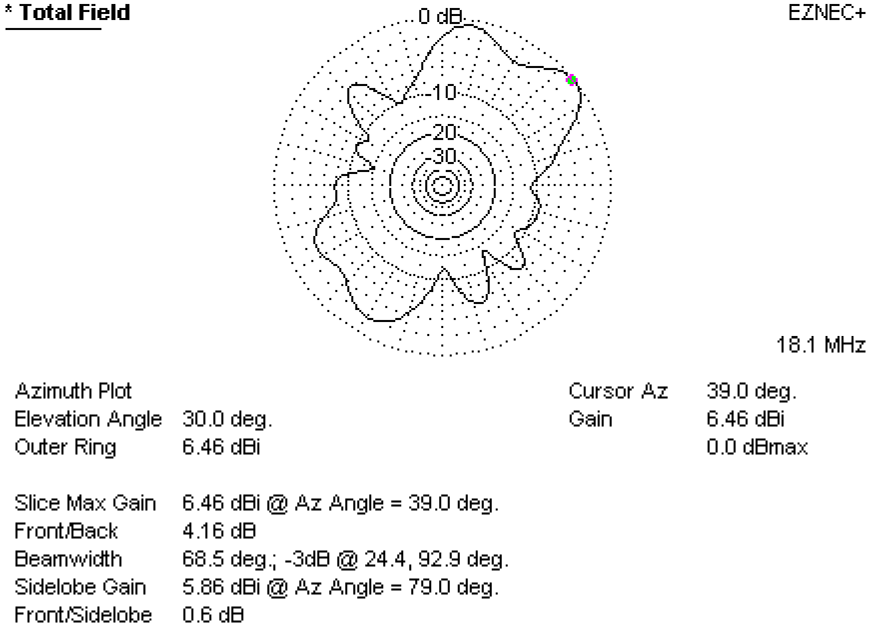
Slice Max Gain 2.24 dBi @ Az Angle = 21.0 deg.
Front/Back 5.97 dB
Beamwidth 34.7 deg.; -3dB @ 6.6, 41.3 deg.
Sidelobe Gain 2.24 dBi @ Az Angle = 85.0 deg.
Front/Sidelobe 0.0 dB

Figure 10. Dipole element azimuth plot at 18.1 MHz.



```
Azimuth Plot                                          Cursor Az    221.0 deg.
Elevation Angle  30.0 deg.                            Gain         -7.61 dBi
Outer Ring       4.08 dBi                                          -11.69 dBmax

Slice Max Gain   4.08 dBi @ Az Angle = 272.0 deg.
Front/Back       0.24 dB
Beamwidth        72.7 deg.; -3dB @ 251.0, 323.7 deg.
Sidelobe Gain    3.85 dBi @ Az Angle = 93.0 deg.
Front/Sidelobe   0.23 dB
```

Figure 11. Loop antenna azimuth plot at 18.1 MHz.



```
Azimuth Plot                                          Cursor Az    39.0 deg.
Elevation Angle  30.0 deg.                            Gain         6.46 dBi
Outer Ring       6.46 dBi                                          0.0 dBmax

Slice Max Gain   6.46 dBi @ Az Angle = 39.0 deg.
Front/Back       4.16 dB
Beamwidth        68.5 deg.; -3dB @ 24.4, 92.9 deg.
Sidelobe Gain    5.86 dBi @ Az Angle = 79.0 deg.
Front/Sidelobe   0.6 dB
```

Figure 12. Hybrid antenna azimuth plot at 18.1 MHz.

and physical capabilities of most individuals). When available property is an active constraint, one should not hesitate to experiment with non-traditional configurations and can have confidence in the predictions afforded by readily available MoM numerical codes such as EZNEC.

It is true that a land width requirement was introduced in this case. However, the area under the composite hybrid antenna detailed in this paper is less than 0.2 acres, a land requirement that is generally not preclusive. The results of this study, both the numerical analysis outputs and the experience of on-air use, agree and conclude that the hybrid antenna is fully equivalent (and even superior at some spatial angles) in electrical performance to a full sized half-wave dipole at 40 feet height.

Not only are the received/transmitted signal strengths noticeably better with this configuration in comparison its half-square predecessor, but the susceptibility of the half-square to local vertically polarized noise sources is considerably reduced. Indeed, it would be a fair characterization to describe the hybrid described here as a quiet receiving antenna.

A significant bonus is that, since the hybrid was the product of judiciously combining two already existing antennas, the two “element” antennas remain available for use by introducing a switching box as described above.

The author would welcome reports from any practical communicators of similar developments they achieve that are either derived from, or at least inspired by, the contents of this paper. In addition to the work email address furnished as part of the paper title, interested parties may also contact the author via email address k4cww@comcast.net.

REFERENCES

[1] EZNEC is a software product of Roy Lewallen, as described at http://www.eznec.com/.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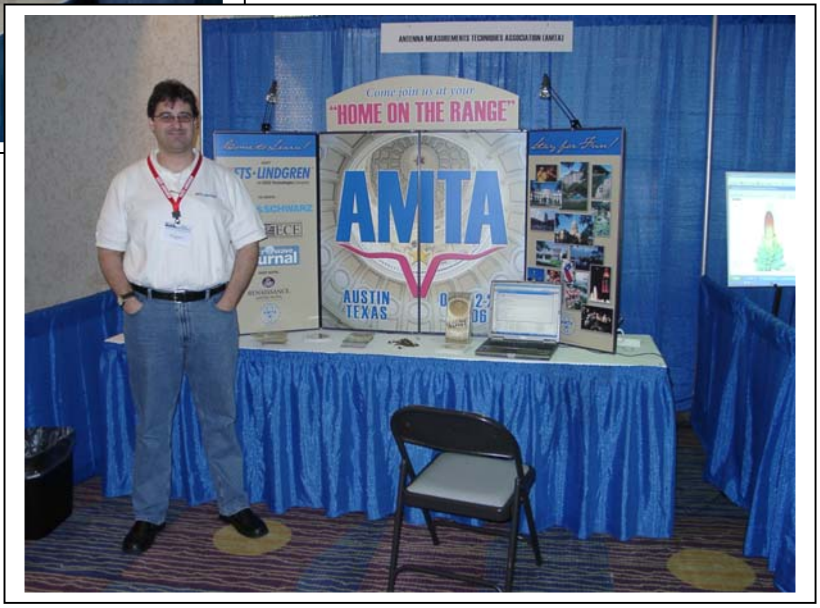
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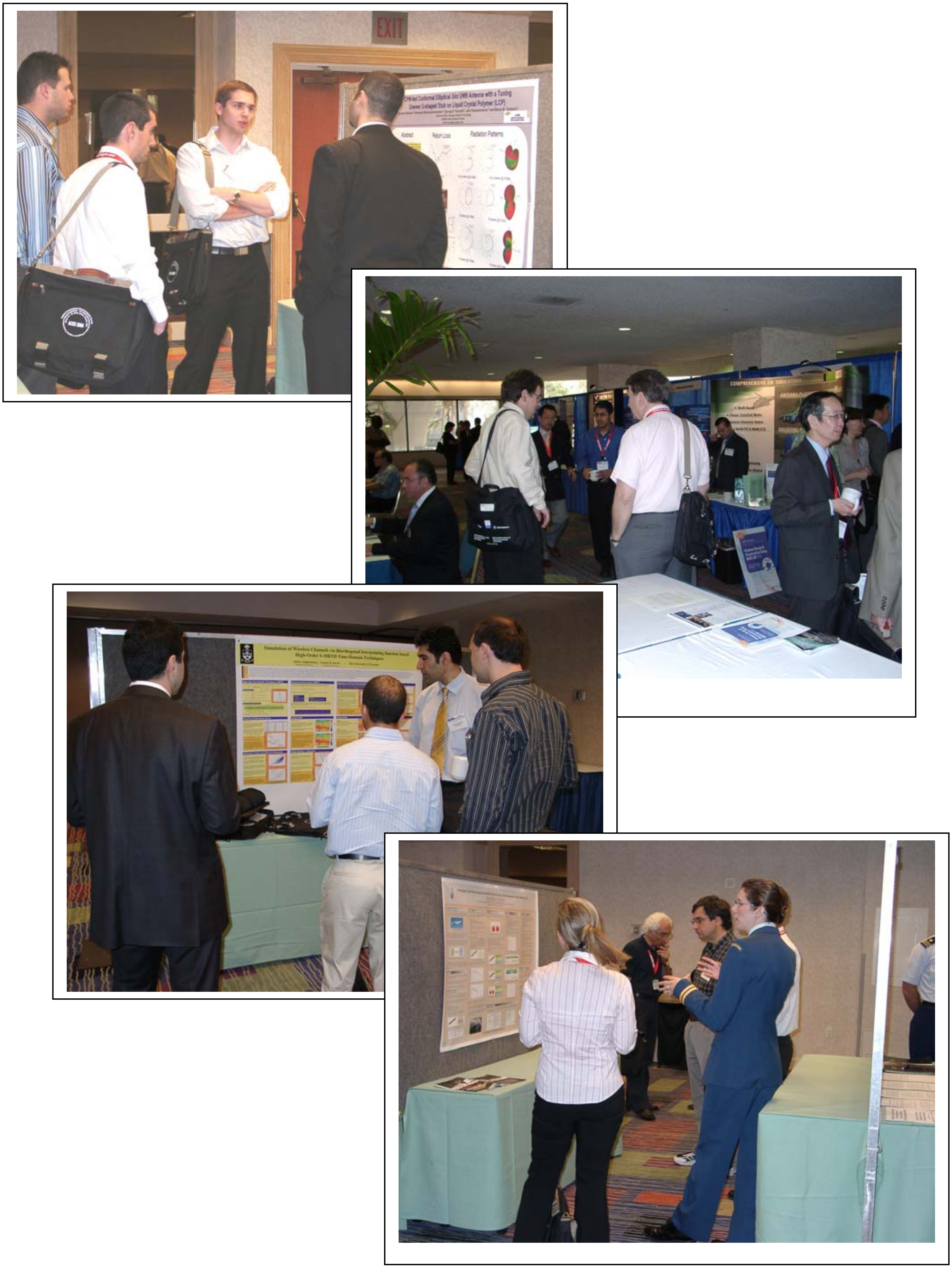
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Maxwell Planck