

APPLICATION OF A MULTI-PURPOSE COMPUTER SYSTEM WITH INTERACTIVE GRAPHICS

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Abstract

A versatile computer system with interactive graphics is being used for the numerical modelling of antennas on aircraft. The PDP-11 based system has been interfaced into an extensive computer network and to laboratory experiments, providing several stand-alone and terminal modes of operation supported by corresponding software. The special man-computer relationship made possible, overcomes the limitations frequently present in simulation studies of real world phenomena that require large-scale computation and which are usually carried out in the "stand-off" mode of batch computation.

The dynamics of the usage of the system is illustrated by an animated slide sequence. The manipulation and display of input files, interaction with host machines, display and comparison of experimental and simulation results in an integrated fashion demonstrate the means by which a special awareness is brought about to assist the creativity and productivity of the researcher.

Résumé

Un système versatile d'informatique complété d'un traceur de courbe interactif est employé pour l'analyse numérique de modèles d'antennes aéronautiques. Ce système à base de PDP-11 a été mis en interface avec un réseau étendu d'ordinateurs ainsi qu'avec des expériences en laboratoire, fournissant surtout plusieurs modes d'opérations de télé-commande (par terminal) et d'autocommande, soutenue par leur logiciel respectif. Cette relation unique entre l'homme et l'ordinateur surmonte, une fois réussie, les limitations souvent présentes dans les études en simulation digitales de phénomènes réels, qui requièrent la programmation de grande envergure, lesquelles études sont habituellement complétées dans le mode "stand-off" du calcul en fournée.

La dynamique d'usage du système est illustrée par une sequence de diapositives de caractère animé. La manipulation et l'étalage des tableaux d'entrée, l'interaction avec les ordinateurs-hôtes, l'étalage et la comparaison des résultats expérimentaux et des calculs de simulation digitales démontrent d'une façon intégrée les moyens par lesquels une conscience spéciale émerge pour assister le chercheur dans sa créativité et sa productivité.

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INTRODUCTION

There are many applications in which interactive computer graphics is becoming a powerful instrument supporting simulation studies of real world phenomena. Interactive graphics can

- provide a flexible display of input files which describe the simulation model, for purposes of model development and verification,
- allow ready execution of the simulation by the local computer itself or by a host computer,
- provide immediate and flexible (interactive) display of simulation results for comparison with results of other computations or real-world results,
- allow an integrated and complete view of results to guide development of improvements in modelling.

The overall effect can be that of restoring to computer modelling the sense of "feel" present in experimental measurements, and usually not present in batch computations on system models.

The numerical modelling of aircraft antennas provides an example of the sequence necessary for the development of successful models and its interactive implementation on a cost-effective PDP-11-based system. In the oral paper the modelling steps are illustrated by an animated slide sequence.

MODELLING METHOD

One method of simulating antennas on complex aircraft structures consists of modelling the antenna and aircraft by a grid of sufficiently short straight wire elements. When the antenna is excited by a voltage source, it gives rise to currents on itself and on the aircraft (or wire grid) elements. These currents determine the antenna's radiation characteristics. An integral equation {1} expressing a net zero tangential electric field on each wire element contains the currents as unknowns.

By the method of moments {2} the integral equation applied on each wire element generates a system of linear equations which is readily solved for the complex amplitudes of the current on each wire element. Once the currents have been found, radiation patterns can be calculated. A suitable aircraft model at HF frequencies (2 - 30 MHz) involves 200-300 elements.

The tabulation of the co-ordinates of the end points of individual wires is a tedious task which must be done manually from drawings. The resulting sets of co-ordinates form the input to the antenna analysis computer program. The graphics system plays an important role at this stage since it allows the display of the element set for validation and correction purposes. Typical models of 3 aircraft are shown in Figure 1. Sections of the model can be "windowed", elements can be tagged for readout of end co-ordinates to test for continuity and the addition or deletion of elements is simply done. An error-free data set is vital to the computation and this mode facilitates its production quickly and with a heightening of interest.

The incorporation of the data set into an executable module on a host machine is routine and is done through the SIMTEK* software {3} (see Table II). With large models, the computations are substantial and costly (approximately \$100.00/run). Batch computations usually produce solutions as listings of currents (complex values) for each element, tabulations of radiation pattern data or printer plots of radiation patterns in rectangular form. The analysis of this information and its comparison with experimental results is again lengthy and tedious and continuity of analytical thought is difficult to maintain and support.

In contrast, this information is much more readily analyzed and understood using the PDP-11 interactive graphics system. The 'spooling' feature of the SIMTEK emulator allows the transfer of the computed results directly onto a PDP-11 disk. It may then be displayed in a meaningful format, which allows direct comparison with validating experimental results and which can be manipulated more or less at will. Such a graphics display is shown in Figure 2, and consists of the composite presentation of model, current distribution and both measured and computed pattern results for both polarizations. Experimental patterns in analog form are digitized by special software using the XY plotter and joystick. The association of currents (causes) with patterns (effects) is of special significance to the designer-analyst. The process can be readily iterated with altered models and stored results can be compared quickly and effectively. Hardcopy is available for back-up or off-line comparison.

The information of Figure 2 represents the radiation pattern distribution of the antenna in the three principal planes. A more complete 3-D representation is available by the use of a HIDDEN LINE routine which can include other angular pattern distributions (Figure 3). This type of format when related to current distribution

*A PDP-11 Simulator/Emulator of the Tektronix 4010 Terminal

and the antenna model itself, forms an integrated presentation which provides great 'visibility' and comprehension of the results. The interactive display/analysis/change/display/analysis begins to provide the sense of appreciation or "feel" necessary for creative analysis or design.

DESCRIPTION OF THE SYSTEM

The system described has the features and applications shown in Table I. The right hand portion lists the present uses of the system. The flexibility represented is a feature desired by many institutions but requires the development of specialized hardware and software which is sometimes beyond their reach.

The block diagram of Figure 4 shows the major components of the system. It was designed for modular evolution over a period of years and indeed constructed in this modular way with essentially in-house effort. The modular approach was also applied to software development. Figure 4 also lists the major software and hardware items developed locally {3}.

The application described here uses the Direct Terminal Mode (IIb of Table I). Other hybrid modes are evident from a close examination of Figure 4 and serve the additional or back-up purposes shown in Table I. Representative commands from a typical session are shown in Table II.

LIMITATIONS AND FURTHER DEVELOPMENT

The present asynchronous communications speed with the CDC 6400 is too slow and is being upgraded. Storage limitations and operational problems with a single disk drive are frequently encountered.

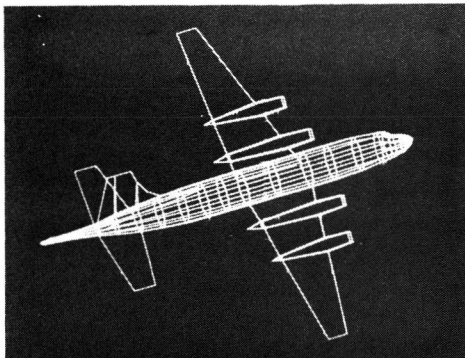
The application of colour graphics to this use is most inviting but inaccessible at present. Plans have been made, however, to expand the architecture to provide for this possibility. It would be logical then, to upgrade the PDP-11/20 to a more powerful processor in that same family.

A project has now been undertaken for linking of microprocessor controlled current distribution measurements with the system (Figure 4), and also to provide access to experimental pattern measurement files from McGill's anechoic chamber by means of file transfer from the IBM 370/158.

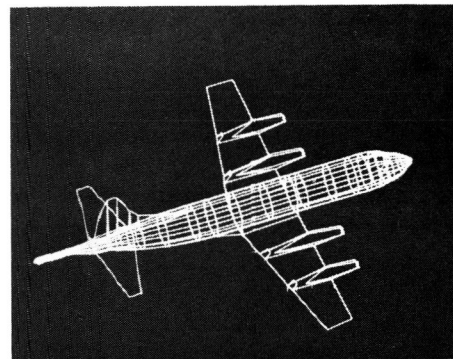
In all other respects the facility has become a powerful instrument for applications in electromagnetics, mechanical engineering and computer science.

REFERENCES

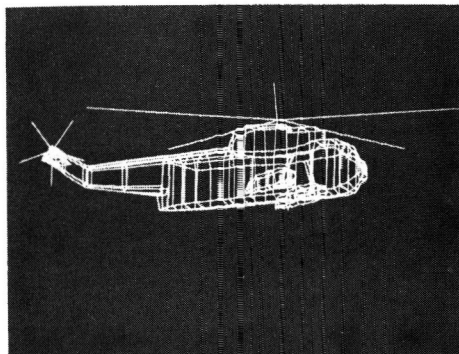
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CL-28/ARGUS LONG RANGE
PATROL A/C



CP-140/AURORA LONG RANGE
PATROL A/C



CHSS-2 SEAKING HELICOPTER

FIGURE 1. WIRE-GRID MODELS OF CANADIAN AIRCRAFT.

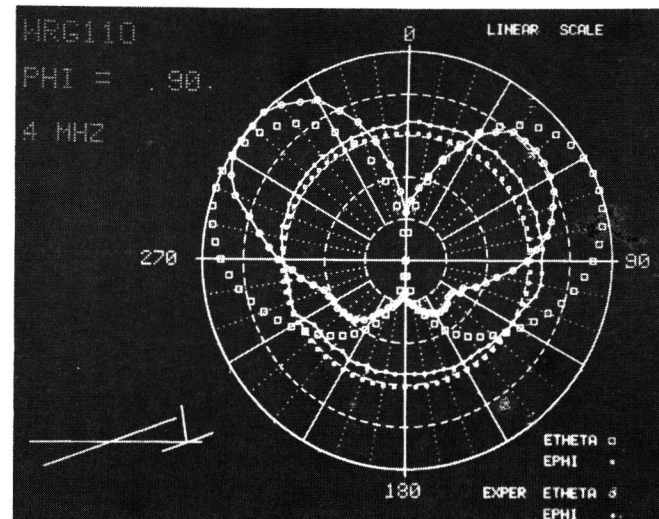
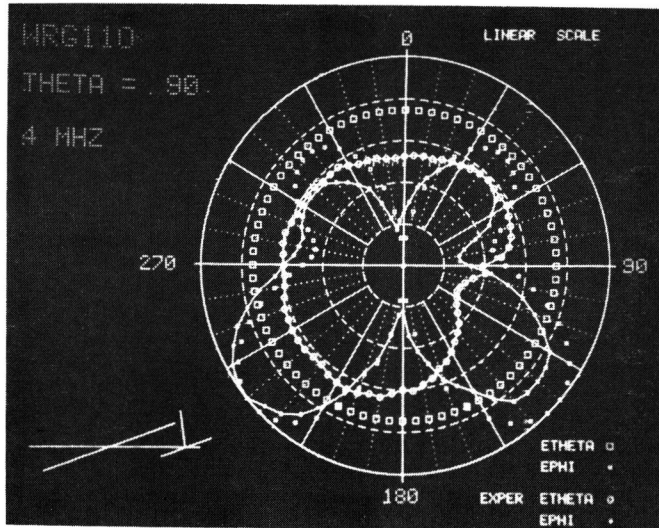
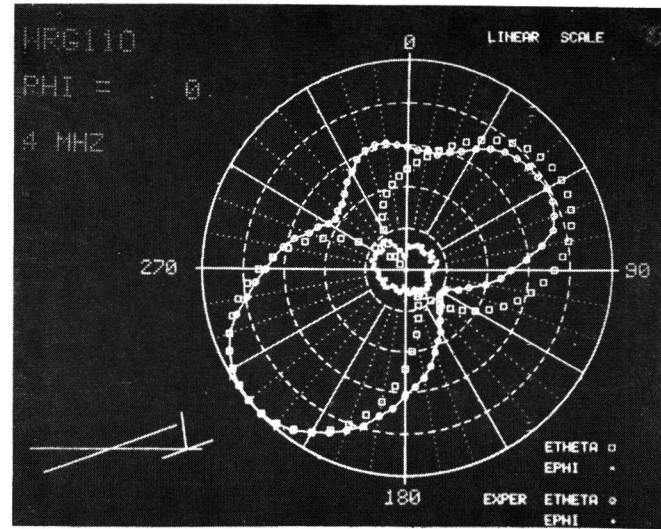
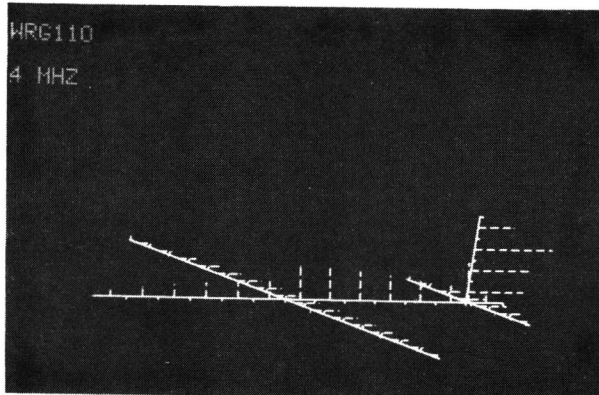


FIGURE 2. MODEL, CURRENT DISTRIBUTION, PRINCIPAL PLANE RADIATION PATTERNS.

TABLE I - SYSTEM REQUIREMENTS & USAGE

Mode of Use	Requirements - Primary		Secondary Requirements	Application Examples
	System	Display		
I. EXPERIMENTAL CONTROL				
a) STAND-ALONE	Real-Time Data Acquisition	Output Data Presentation	Stand-Alone Processing Interconnection with larger host machine	NMR Spectroscopy SCR Machine Control Frequency Analyzer RF Current Distribution
b) Host	Accept LSI-11 Communications	As above	Background Processing	RF Current Distribution
II. ANALYTICAL				
a) STAND-ALONE	Sufficient Processing Power	Flexible Display: - Input File/Geometry - Results in Various Formats . Rect . Polar . 3D - Easy Comparison of Results - Joystick/Cursor		Moment Method Program Development; GTD Analysis Logic Circuit Analysis
b) Direct Terminal	Storage/Manipulation of Files Communications - asynchronous Spooling	As in II(a)	Background Processing Host Computer Graphics	Large-Body Problems in Electromagnetics Combustion Instability
c) Hybrid Terminal	As in II(b) High Speed Synchronous Communications Spooling	As in II(a)	Background Processing Host Computer Graphics	Large-Body Problems in Electromagnetics Combustion Instability

TABLE II - COMMANDS

.R SIM300

***** SIMTEK *****

TEKTRONIX 4010 GRAPHIC TERMINAL SIMULATOR

DO YOU WISH TO OPERATE IN LOCAL OR IN REMOTE MODE?
(ENTER 0 FOR LOCAL, 1 FOR REMOTE)
?1 REMOTE!

TYPE 1 FOR FULL-DUPLEX MODE (NO LOCAL ECHO) :

* READY *

1
77/03/18, 13.35.02.
NOS 1.1 CONCORDIA UNIVERSITY, NOS 1.1-419
USER NUMBER: DAEGI73
TERMINAL: 21.TTY
RECOVER /SYSTEM: PROJECT.ANDRET

READY.
OLD:WRG110

READY.
^O
#WRG11.SIM=
^N
BYE

DAEGI73 LOG OFF 13.36.49.
DAEGI73 SRU 1.000 UNTS.

^C

*** GOODBYE ***

SIMTEK
'SPOOLING'
FROM
CDC
TO
PDP-11

.R WRG3DB

TYPE THE NAME OF THE INPUT FILE
*WRG11.DAT

TAIL CAP, 4 MHZ, 1M IN DIAMETER

?? TYPE THE NAME OF THE RUN. (<7 CHARACTERS)
WRG110

?? TYPE THE FREQUENCY (E.G. 2MHZ).
4 MHZ

?? DO YOU WANT CURRENTS?
Y

TYPE IN THETA ANGLE
60.

TYPE IN PHI ANGLE
50.

?? DO YOU WANT ANOTHER PLOT?
N

?? DO YOU WANT THE PLOTS IN DB SCALE?
Y

TYPE 1 UP TO 9 FOR CORRESPONDING PATTERN
7

?? DO YOU WANT EXPERIMENTAL RESULTS?
0

TYPE Y OR N ONLY! TRY AGAIN!

?? DO YOU WANT EXPERIMENTAL RESULTS?
Y

TYPE THE NAME OF THE INPUT FILE
*TC4.DAT

TAIL CAP, 4 MHZ, THETA =60.90.114 AND PHI=0.90.

TYPE 1,2,3,4,5 FOR THETA=60,90,114 OR PHI=0,90 RESPECTIVELY
3

?? DO YOU WANT ANOTHER PATTERN? ***
N

JUST TO MAKE SURE!

FOR DRAWING TYPE 1
FOR POLAR PLOT TYPE 3
TO STOP TYPE 4

4

STOP --

LOCAL
GRAPHICS
DISPLAY
OF
RESULTS

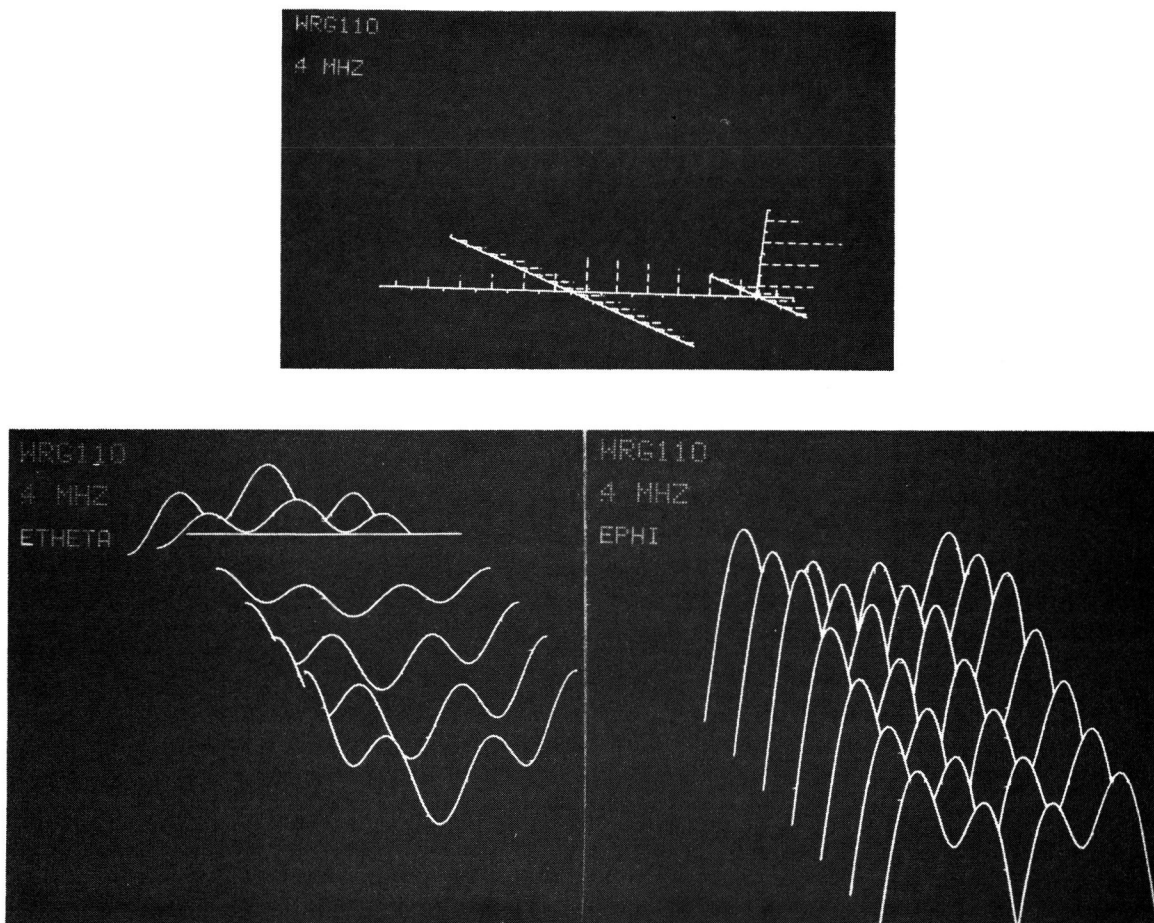


FIGURE 3. MODEL, CURRENT DISTRIBUTION, PATTERNS:
7 VALUES OF POLAR ANGLE.

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