

## COMPUTER GRAPHICS IN THE F. T. McCLURE COMPUTING CENTER

In this day of high-volume data generation, computer graphics is an essential tool for understanding data relationships, analysis, and presentation. APL's F. T. McClure Computing Center is providing many of the computer graphics tools needed to support Laboratory efforts.

### INTRODUCTION

Computer graphics is one of the major growth factors in the computing industry today. The computer has promoted rapid growth in all technologies by means of its ability to analyze data quickly. However, few people can scan a complex computer-generated table of numbers and reach a sound conclusion from the data. Thus, there is a need to convert those numbers into an easily analyzable form—graphics.

Within APL, approximately 400 terminals are being used with the IBM 3033 multiprocessor of APL's Central Computing Center, the F. T. McClure Computing Center. Over half of them are color graphics terminals. This large number of graphics terminals, coupled with a centralized graphics hard-copy system, makes computer graphics accessible to the entire Laboratory.

While a number of stand-alone graphics workstations and other graphics systems exist elsewhere, this discussion is confined to the hardware and software primarily supported by the F. T. McClure Computing Center. Image processing systems, the topic of a previous article,<sup>1</sup> are excluded from this discussion.

### GRAPHICS SOFTWARE

Graphics software available on the IBM 3033 under the Multiple Virtual Storage/Time Sharing Option system includes the well-known commercial packages shown in Table 1. In addition, numerous internally developed graphics subroutines and programs provide capabilities such as flowcharting, viewgraph production, and management graphics. Most of these packages interface with the variety of cathode ray tubes and hard-copy hardware described in the following section. The SAS/GRAPH package is also offered on the IBM 4341 under the Virtual Machine/Conversational Monitoring System.

Many of the software systems shown in Table 1 are device-independent (e.g., DISSPLA, PLOT79, SAS/GRAPH), allowing the generation of graphic displays on the various terminals and plotters described below. Output from device-dependent graphics software (e.g., CAM, SPEAKEASY), originally developed for displaying graphics on only one device, can be dis-

played on many devices through the use of laboratory-developed device-emulator software.

### GRAPHICS HARDWARE

#### Cathode Ray Tube Displays

Graphics terminals connected to the F. T. McClure Computing Center computers are distributed throughout APL. In addition, the Center has placed graphics terminals in general-use areas, for use by all Laboratory staff. Typically, the terminals are used to preview plots which are subsequently sent for hard copy from one of the devices described in the next section.

Approximately 150 IBM 3279 eight-color graphics terminals are currently in use with APL's 3033. The terminals are distributed throughout all departments, and many are dedicated to classified processing. Many models of Tektronix and Hewlett-Packard graphics terminals, IBM personal computers, and several Grinnell image-processing workstations are also used for computer graphics from the 3033.

#### Screen Hard Copy

Instant screen hard-copy units include approximately 20 IBM 3287 four-color dot matrix printers and numerous Tektronix 4631 and 4632 copiers. Those devices serve the needs of most users who require quick hard-copy for debugging and data analysis. The IBM program product, ADMPRINT, allows the IBM 3287 printers to be shared among the many IBM 3279 terminals.

#### High-Resolution Hard Copy

Spooling systems are used to provide centralized processing on several high-resolution hard-copy devices. Turnaround is generally less than six hours.

Two CalComp digital plotters provide four-color hard copy on paper up to 32 inches wide. A Hewlett-Packard 7221 provides for the direct generation of transparencies with up to eight colors. A Dicomed D48C color-film recorder, controlled by a PDP-11/70 computer, produces 35 millimeter color slides, 8 by 10 inch transparencies, or monochrome microfiche. Various printing services are provided by the APL Central Photographic Laboratory for producing poster

**Table 1** – Commercial computer graphics software.

<i>Software Package</i>	<i>Type</i>	<i>Primary Uses</i>
DISSPLA	Subroutine library	Maps, data analysis plots, movies
TELL-A-GRAF	Command-driven program	Business and presentation graphics, report graphics, "quick-and-dirty" plots
CUECHART	Prompting program	Standard format data-representation graphics: line, bar, pie, and text charts
TELL-A-PLAN	Command-driven program	Project management graphics, Gantt charts
GRAPHPAK	Function library	Provides simple graphics to users of the APL language: x/y graphs, bars, histograms
SAS/GRAPH	Procedure library	Statistical data representation graphics: bar, pie, line, and star charts
CAM	Command-driven program	Mapping applications
PLOT79	Subroutine library	Molecular diagrams, x/y graphs, 3-D surfaces, contour plots
NCAR	Subroutine library	Maps, vector flow diagrams, scatter diagrams
GDDM	Subroutine library	Primarily used as interface from other packages to the IBM 3279 and 3287
SPEAKEASY	Command language	Mathematical data analysis with x/y graphics and 3-D wireframes
MOVIE.BYU	Command-driven program	Animation, continuous tone shading of solid objects, wireframes

size prints and nonstandard formats from 35 millimeter film.

## APPLICATIONS

APL is using computer-generated graphics in support of a wide variety of programs. Classified processing is made possible by confining dedicated graphics terminals to closed areas and by using various spooling systems to centralized hard-copy units. The applications discussed below are representative of three major categories of graphics generation: animation, data analysis, and report generation.

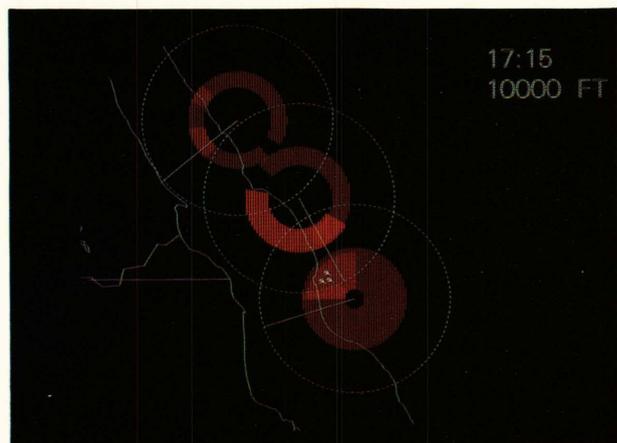
### Anomalous Radar Propagation Movie

The study of the anomalous propagation of radar caused by nonstandard atmospheric conditions is an ongoing project at APL.<sup>2</sup> This research prompted the development of a computer-generated movie to show such effects graphically. The movie was produced on the IBM 3033 using a program written in the PL/I and Fortran languages and accessing DISSPLA, a library of Fortran graphics subroutines. The Dicomed film recorder was used as the final output device.

The 20 minute movie, entitled "Anomalous Propagation and Radar Coverage," is composed of over two dozen scenes in approximately 30,000 frames. First, the fundamentals of radar propagation are illustrated. Then, atmospheric effects such as subrefraction, superrefraction, elevated ducts, and surface ducts

are depicted, and radar coverage from multiple sites is examined. Finally, a simulation is shown in which intruder attack aircraft exploit the coverage holes caused by the anomalous propagation of the radar beam. Several scenarios are examined. Figure 1 shows a scene from the simulation.

The computer program development involved two programmers on a part-time basis over a period of



**Figure 1**—Scene from color animation depicting intruder aircraft flying in radar coverage holes caused by anomalous propagation of radar. The white circles show areas of maximum radar coverage; the red areas show voids in radar coverage caused by anomalous propagation.

about six months. DISSPLA was chosen as the primary graphics software because it provides a rich environment for animation and allows many details to be described in a few subroutine calls. Its high-resolution graphics fonts and full-color selection contribute to the film's high quality.

The film recorder was not practical as the primary output device for test runs during development of the animation program. Instead, the IBM 3279 terminal was used to preview selected frames, and the IBM 3287 printer was used for hard copy of the sampled frames. The output of the program was ultimately recorded on tape in Dicomed machine code and was transferred to the PDP-11/70 computer controlling the Dicomed film recorder. Control over the output device and many other parameters was achieved by reading an initialization file containing color, movement, and output device information.

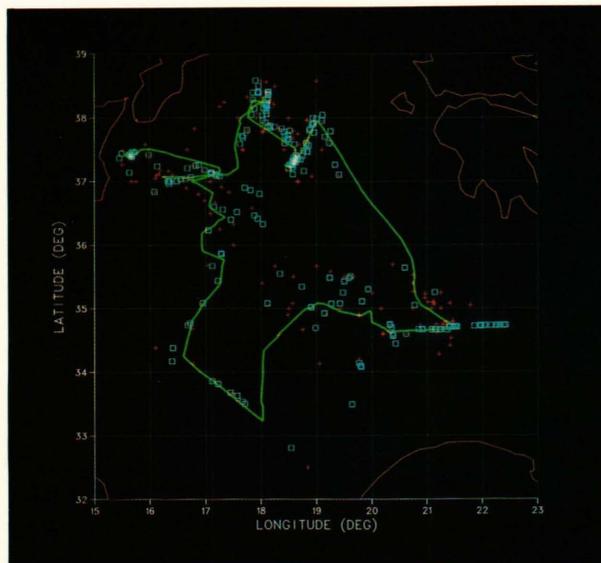
Processing time on the IBM 3033 is reduced by means of a feature known as segmentation. With segmentation subroutines, the program describes the static portion of each scene (such as the background map) only once during program execution on the 3033. But when the tape thus generated is processed by the Dicomed/PDP, each segment is stored locally on an auxiliary disk. A segment may then be recalled locally for each frame as the film is being exposed. This feature saves 3033 processing time by eliminating the need to reprocess each frame completely on the host.

The movie has been shown to international audiences studying these atmospheric effects and has proved to be an effective way to describe this complex phenomenon.

### Ship-Tracking Algorithm Analysis

The Interactive Display System was developed for the APL Fleet Systems Department in support of the Correlator/Tracker Development Task of the Over-the-Horizon/Detection, Classification, and Targeting Engineering Analysis Program.<sup>3</sup> The interactive graphics program constructs various types of displays in support of ship-tracking algorithm development to aid the analyst in visualizing interrelationships between actual data and data estimated by algorithms. Data collected during Fleet over-the-horizon targeting exercises are displayed along with the output of ship-tracking algorithms to help analyze visually the algorithms' accuracy. Figure 2 is a representative display showing ground truth positions, reported positions, and algorithm-estimated positions.

The Interactive Display System is an interactive, menu-driven program written in the PL/I language with graphic output produced by calls to DISSPLA subroutines. Data are read from external files. A special command language is defined that allows the user to extract subsets of data, combine different data sources, specify plotting options, and construct multicolor displays on a IBM 3279 graphics terminal, or to produce hard copy for analysis or presentation us-



**Figure 2**—The Interactive Display System program produces multicolored displays comparing ground truth data (green line), sensor-recorded data (red pluses), and algorithm-estimated locations (blue squares) of ships to help analysts visualize algorithm accuracy.

ing the 3287 printer, Dicomed film recorder, or Hewlett-Packard plotter.

As a result of this successful program, the new Correlator/Tracker Evaluation Laboratory has been established. The existing Interactive Display System will be enhanced to provide more interactive capabilities, including windowing on areas of interest and data extraction using tablet interaction with the terminal display.

### Automated Report Graphics System

Computer graphics is being used by the System Studies and Simulations Group of APL's Strategic Systems Department to automate the production of their report and presentation graphics.<sup>4</sup> Annually, approximately 100 graphs are generated for summary publications and briefings describing accuracy and reliability analyses of strategic weapon systems. The automated system replaces the traditional method of having graphs drawn by layout artists to meet publication specifications. It takes advantage of graphics software and hardware on the F. T. McClure Computing Center systems to produce publication-quality graphics in final camera-ready form. The graphics system combines SAS, a well-known database and statistical analysis system, with TELL-A-GRAF, a command-driven, publication-quality graphics program. TELL-A-GRAF was selected because of its design flexibility, which allows one to meet strict publication standards.

Raw data are stored in SAS databases and, when needed, are extracted and manipulated by means of SAS. A special SAS procedure, PROC TAG, generates a file containing the appropriate TELL-A-GRAF commands merged with the extracted data. TELL-A-

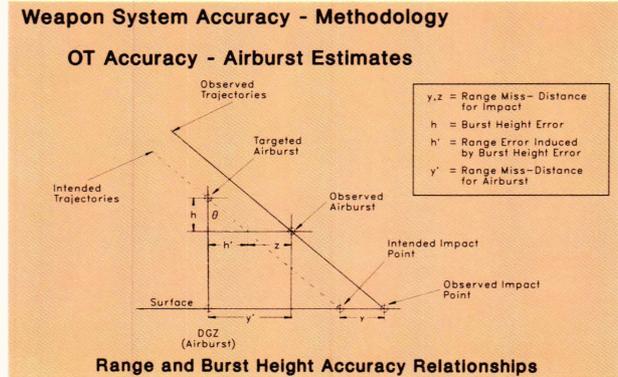
GRAF is then used to produce the graphs that are output on the Dicomed film recorder to create final publication-quality prints or presentation viewgraphs. Figure 3 is an example of such a graph. If color is required in the report, color separation plots ready for printing can be produced on the CalComp plotter.

This automated system has major advantages over the traditional methods. When changes in data or analysis methods occur, the system facilitates a quick response to maintain production deadlines. The plotted data have computer accuracy, which might otherwise be lost in transcription. Additionally, standard report and presentation graph command files are stored on-line for reuse. This cuts the cost of future report generation, ensures uniform publication quality and format, and promotes further enhancement of the graphics system.

### FUTURE PLANS

The computer graphics industry is growing at the rate of 30% per year, as new products and technological improvements are unveiled daily. Paralleling this growth, the need for automated graphics tools through APL's central computing facility is expected to grow dramatically over the next few years. The use of computer graphics is expanding to support the range of Laboratory functions. Not only is graphics needed in the technical areas in support of ongoing projects, but it is needed as a tool for project managers, administrators, budget analysts, and artists.

The technical staff of the Information Systems Group (TCI) recently completed a study of APL's requirements for enhanced graphics capabilities. Plans are under way to provide more interactive software and hardware, workstations, and higher quality, quicker turnaround hard-copy graphics output devices including text and graphics integration for complete report production. Enhancements are being considered to provide centralized, high-quality graphics hard-copy



**Figure 3**—Plot generated on the Dicomed film recorder using TELL-A-GRAF software. Graphics such as this are used directly in the printing process, saving time and preserving accuracy. This graph was used in briefing sessions on a weapon system evaluation report.

facilities and other graphics services to the rapidly expanding number of personal computer users at APL.

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