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Michael C. Nesel and Kevin R. Hammons
Ames Research Center, Dryden Flight Research Facility, Edwards, California

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REAL-TIME FLIGHT TEST DATA DISTRIBUTION AND DISPLAY

Michael C. Nesel* and Kevin R. Hammons**

NASA Ames Research Center
Dryden Flight Research Facility
Edwards, California

Abstract

This paper describes enhancements to the real-time processing and display systems of the NASA Western Aeronautical Test Range (WATR). Display processing has been moved out of the telemetry and radar acquisition processing systems (TRAPS) super-minicomputers into user/client interactive graphic workstations. Real-time data is provided to the workstations by way of Ethernet. Future enhancement plans include use of fiber optic cable to replace the Ethernet.

Nomenclature

CVT	current values table
EU	engineering units
MAGIC	master graphics interactive console
MCC	mission control center
TCP/IP	Transmission Control Protocol/Internet Protocol
TM	telemetry
TRAPS	telemetry and radar acquisition processing system
RIM	real-time interactive map
WATR	Western Aeronautical Test Range

Introduction

The real-time processing and display systems element of the NASA Western Aeronautical Test Range (WATR) has been enhanced to include high-resolution interactive programmable graphics workstations. Display processing has been moved to the workstations from the telemetry and radar acquisition processing system super-minicomputers (TRAPS). Real-time data are transmitted from the TRAPS to the workstations through Ethernet. Use of intelligent programmable workstations for graphic displays substantially reduces the TRAPS workload, allows for sophisticated three-dimensional graphics without impacting the critical acquisition system software, and provides greater flexibility in display design and reconfiguration.

Western Aeronautical Test Range

The NASA Western Aeronautical Test Range (WATR) of Ames Research Center conducts aeronautical research missions (Fig. 1) within the largest inland test range in the continental United States (Fig. 2). The WATR provides mission control centers (MCC), communication and tracking systems, and real-time computation and display capabilities to support a wide variety of aircraft (Fig. 3).[1]

At Ames-Dryden Flight Research Facility, 32-bit super-minicomputers are used to provide telemetry and radar data real-time processing and distribution. Ever-increasing complexity and sophistication of research aircraft has in turn demanded more and more of the real-time computer hardware (Fig. 4).[2] Slower computers have been replaced with faster models. Custom memory interfaces and high-speed fiber optic data buses have been designed and fabricated to keep up with the increased demands for real-time information in the mission control center (Fig. 5).

A Measure of Data

Newer research aircraft such as the forward-swept wing X-29 have forced the development of sophisticated real-time graphics displays. All real-time displays in the MCCs have in the past been driven by the primary computational support hardware: the TRAPS computers. As graphics display requirements have increased, the load on the TRAPS has also increased. Newer and faster hardware has provided some relief. Another approach to reducing the load is to move some of the computation outboard to intelligent graphic workstations. This approach has been implemented at Ames-Dryden using high-resolution graphics workstations that receive real-time engineering unit data from the TRAPS computers through Ethernet.

Graphics applications consume large quantities of computer capacity and so are ideal candidates for outboard solutions. Several graphics workstations from various vendors were examined. High-resolution 32-bit UNIX-based (UNIX is a registered trademark of AT&T Bell Laboratories, Murray Hill, New Jersey) interactive graphics workstations were installed (Figs. 6 and 7).

At the same time, engineering unit data distribution methods were examined with an eye to minimizing problems associated with an expected rapid growth in the number of attached workstations. Reasonable data throughput rates and maximum compatibility with future changes in the TRAPS hardware were also considerations. Ethernet was the distribution medium chosen for the workstations.

Add Two Tablespoons of Software

Each TRAPS contains two super-minicomputers connected by 65,536 32-bit words of shared memory. At the TRAPS end of the Ethernet cable, real-time data is converted to engineering units by one of the two TRAPS computers, placed in a current values table (CVT) in a shared memory partition, then extracted from the CVT and distributed over Ethernet by a FORTRAN 77 program running in the second TRAPS computer (Fig. 8). Up to four workstations are serviced, round-robin fashion, at up to ten samples/sec. This FORTRAN program acts as a server, and is activated before the workstations attempt to connect. It should be mentioned that this FORTRAN 77 Ethernet server program is only one of several real-time tasks executing concurrently in the second TRAPS computer.

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* Senior software engineer, Datamax Computer Systems Inc.

** Electronics engineer.

The actual maximum sample rate is most dependent on the number of workstations being serviced. In order to maintain a uniform update rate across all workstations, packets are pushed out immediately as they are formed. Since each workstation may be running a different application, each must be able to control the rate at which it receives data. An acknowledgement scheme is used, whereby each time a workstation reads a data packet, it sends an acknowledgement back to the TRAPS server process. Thus the effective sample rate for each workstation may differ. Currently, each workstation receives data packets customized to its needs; that is, the data sent to workstation "A" is only what it needs, and may be totally different from what is sent to workstation "B." An improved distribution scheme, where all data is available to all workstations regardless of individual requirements, is in the early design stage. This "distributed CVT" design will use fiber optics and custom memory interfaces.

On the client end of the Ethernet cable, interface routines were written in the "C" language, for tasks operating within the UNIX (System V) environment. One set of generic Ethernet interface routines was written, containing the standard I/O functions necessary for a client/receiver task: OPEN, READ, STOP, START, and CLOSE.

Applications, To Taste

Three graphic display applications have been implemented so far using the data distribution mechanisms previously described. The first application to be brought on-line was real-time interactive map (RIM, Fig. 9). The primary purpose of RIM is to replace a two-dimensional pen-and-ink plotboard that traces the path of research vehicles over a preprinted map during a flight (Fig. 10). Radar provides the essential data for this application. A major enhancement to this application, made possible by the use of an intelligent graphics workstation, was to allow alternate views such as a pilot's-eye view or the view from an imaginary chase plane situated just behind the research vehicle.

The second application currently operational is master graphics interactive console (MAGIC). MAGIC is a generalized graph generator producing variable-size plots of y as a function of x and y as a function of time (Fig. 11). Arbitrary polygonal shapes can be overlaid on any of these graphs to delineate critical boundary conditions. Graphs can be sized, positioned, and colored as desired. Up to ten pages, each containing up to 16 graphs, can be defined and stored for later use. MAGIC can also display the data nongraphically in a manner similar to that used on alphanumeric display devices. The data for MAGIC is, of course, obtained in real-time over Ethernet.

The latest application of the Ethernet data bus is a spin alert display for high-angle-of-attack research flights (Fig. 12). These experiments deliberately set up flight profiles with a high probability of inducing a spin condition. If the aircraft does enter a spin condition, ground controllers need to know immediately the state of control surfaces to assist the pilot in recovering from the spin. The spin alert display forsakes the sophisticated three-dimensional capabilities of the graphics workstation and uses position and color on a single page, two-dimensional display to convey information as quickly as possible.

Concluding Remarks

The NASA Ames Western Aeronautical Test Range has successfully extended the useful life of its primary real-time TRAPS computer hardware by off-loading compute-intensive applications to intelligent graphics workstations. Data is supplied to the workstations in real-time by way of Ethernet using the TCP/IP Ethernet protocol. The workstations provide enhanced interactive user/client display systems whose graphics capability does not impact TRAPS operation.

References

[1]Moore, Archie L., "The Western Aeronautical Test Range of NASA Ames Research Center," NASA TM-85924, 1985.

[2]Moore, Archie L., "The Role of a Real-Time Flight Support Facility in Flight Research Programs," NASA TM-86805, 1986.

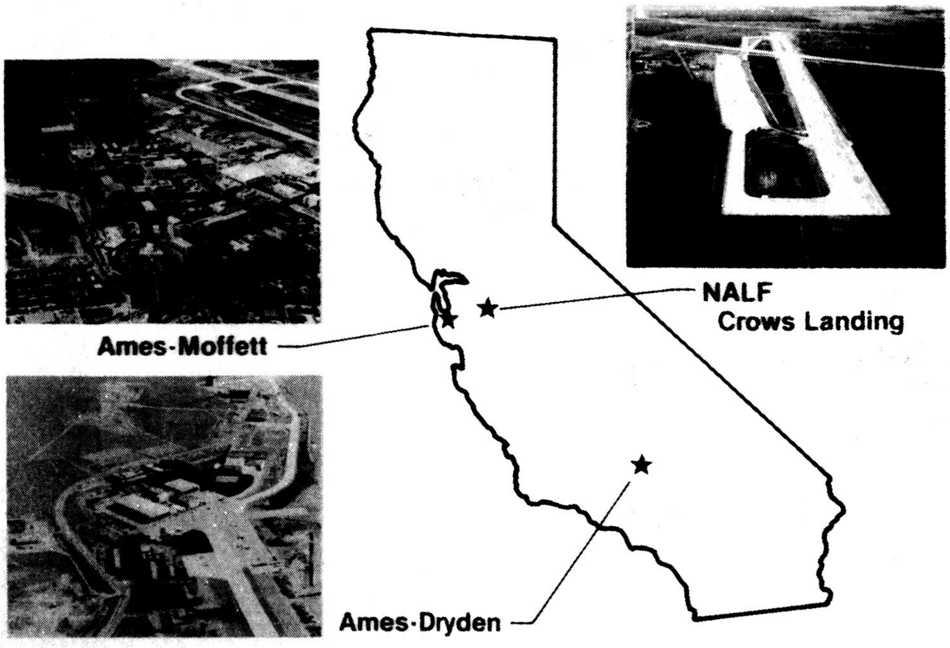

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Fig. 1 Ames Research Center flight operations.

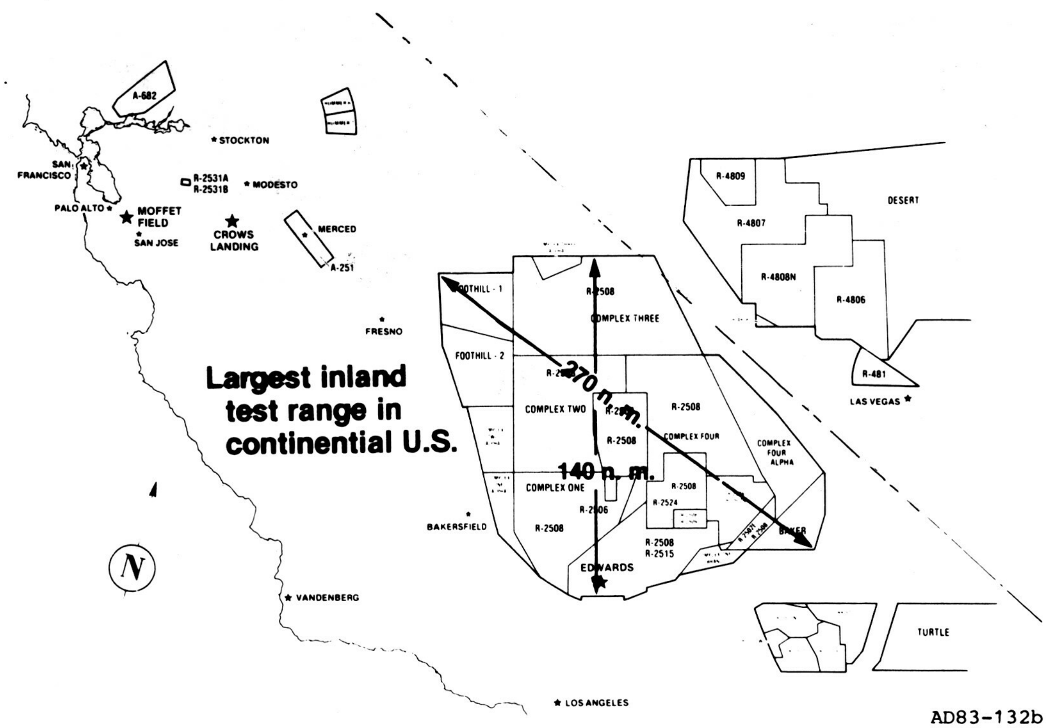

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Fig. 2 Dimensions of Western Aeronautical Test Range.

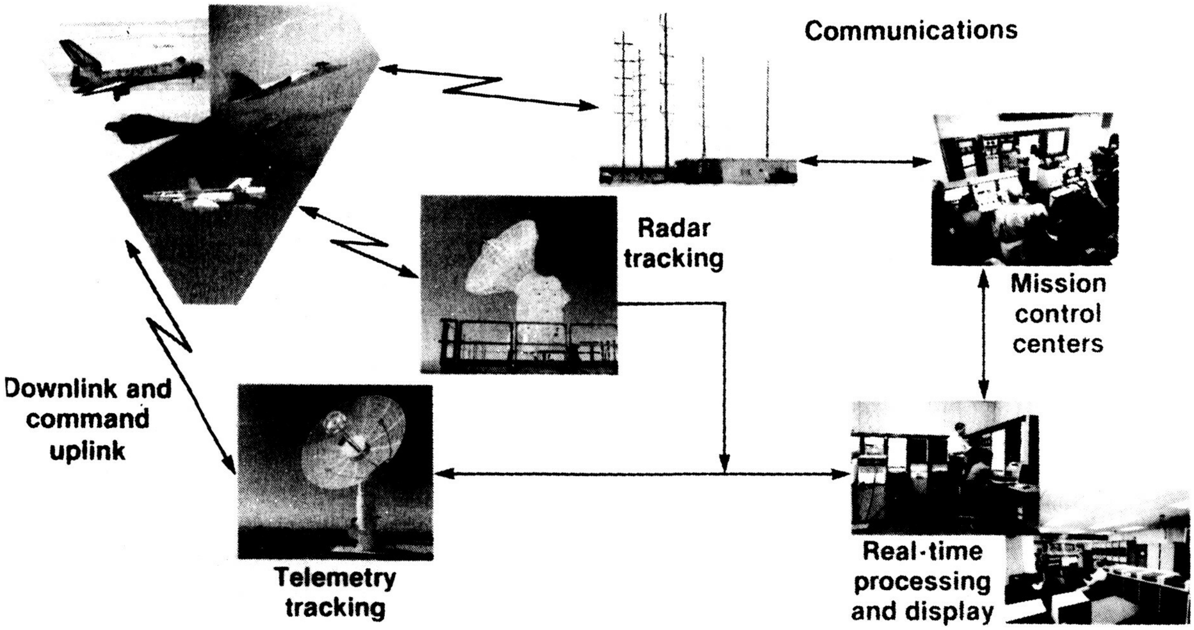

Fig. 3 Components of Western Aeronautical Test Range.

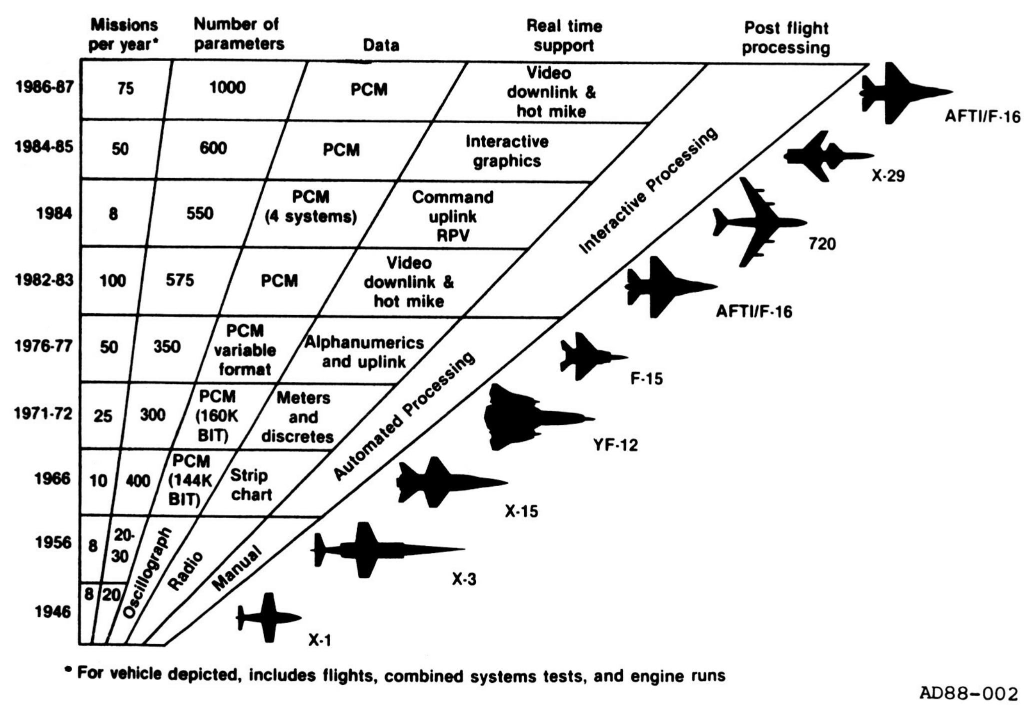

Fig. 4 Evolution of aeronautics program requirements at Ames-Dryden.

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Fig. 5 WATR Blue Room mission control center.

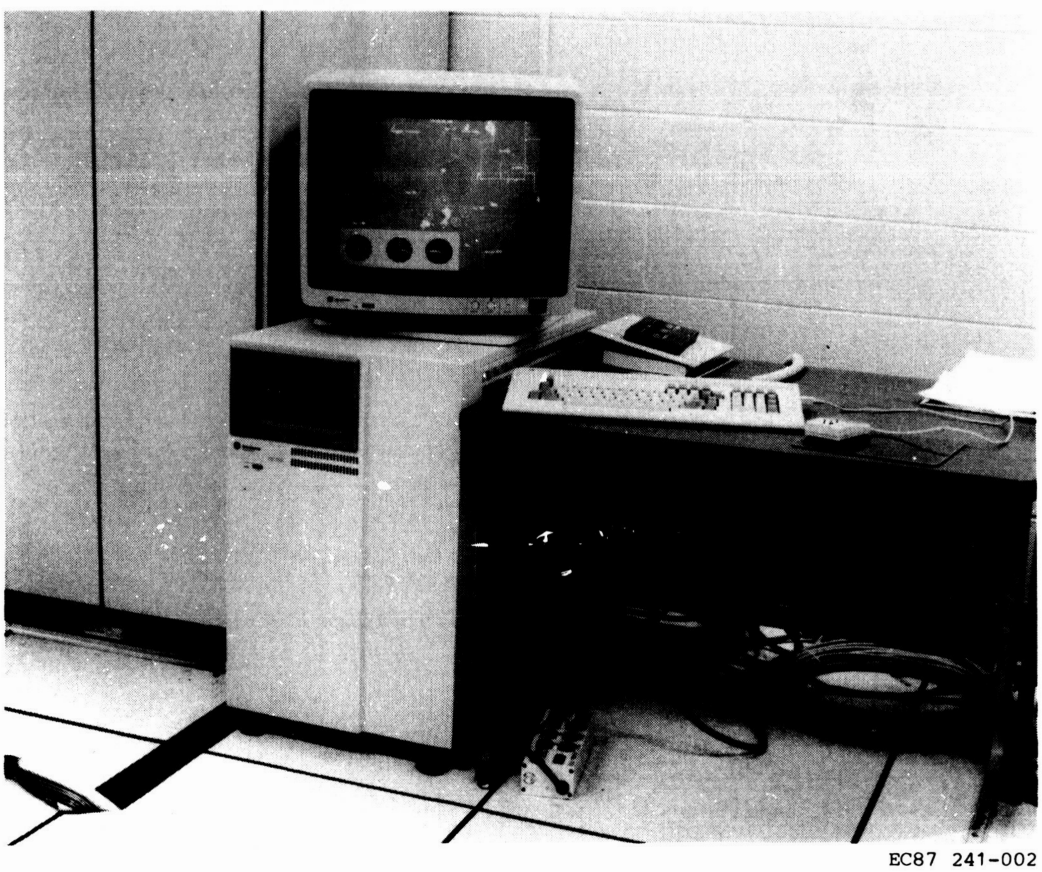

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Fig. 6 Interactive programmable graphics workstation.

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Fig. 7 Mission control center displays.

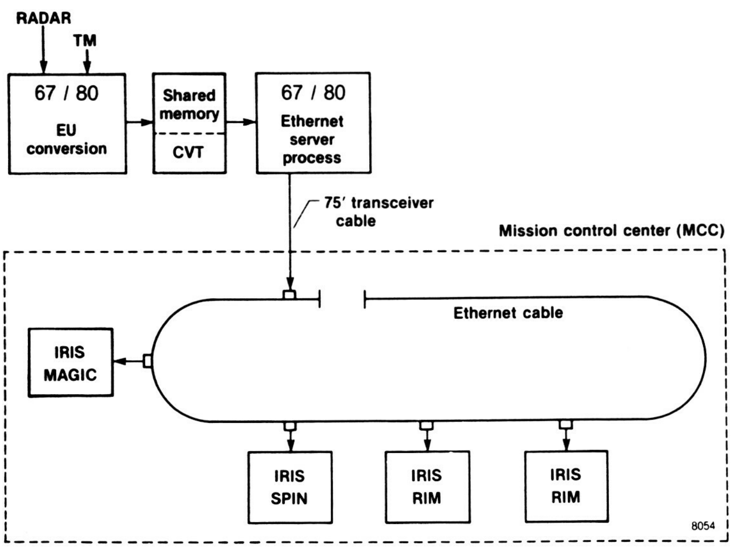

Fig. 8 Real-time data distribution through Ethernet.

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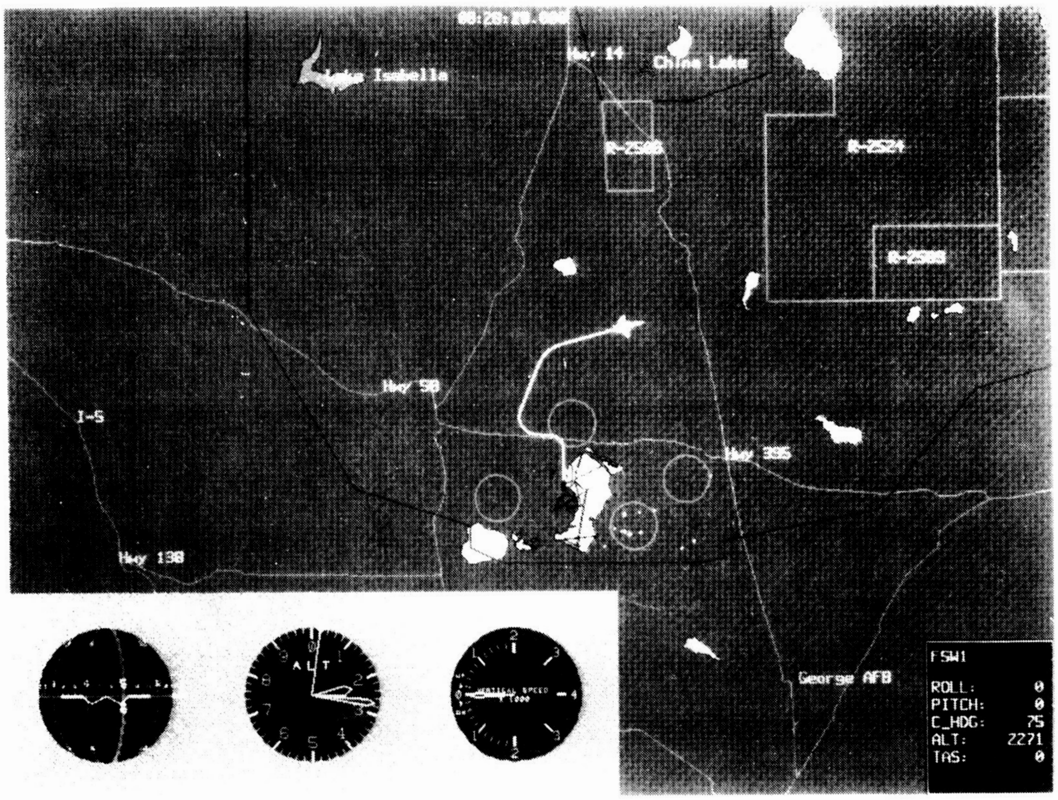

Fig. 9 Real-time interactive map (RIM) display.

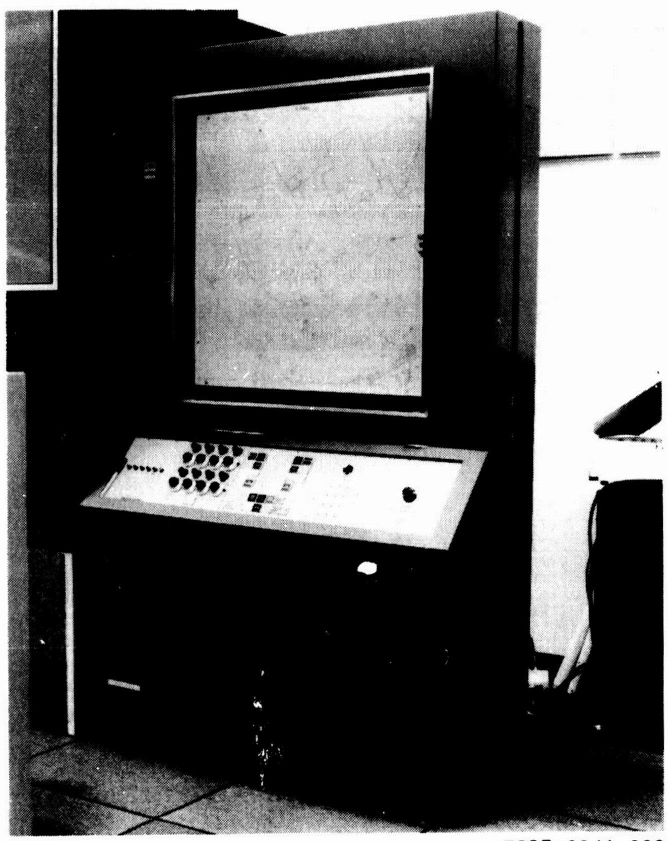

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Fig. 10 Pen and ink X-Y plotter.

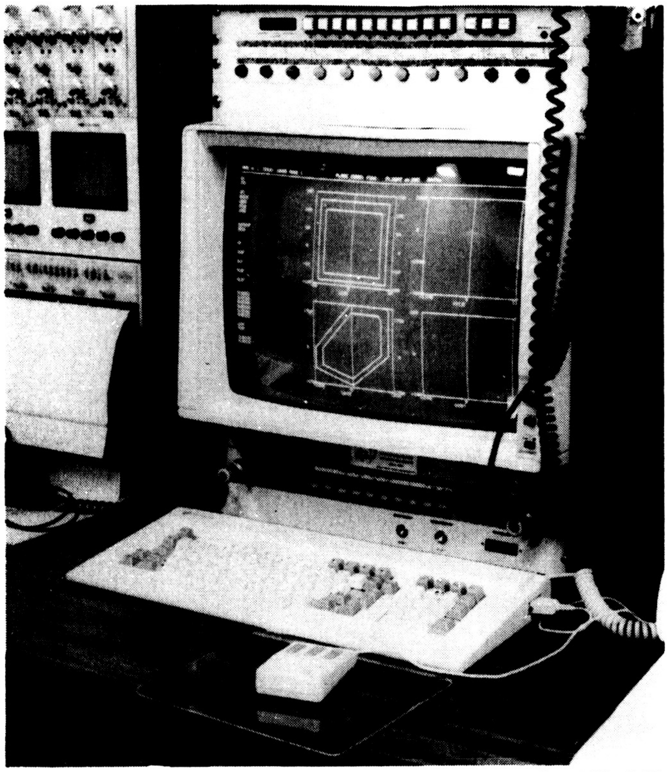

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Fig. 11 Master Graphics Interactive Console (MAGIC) display.

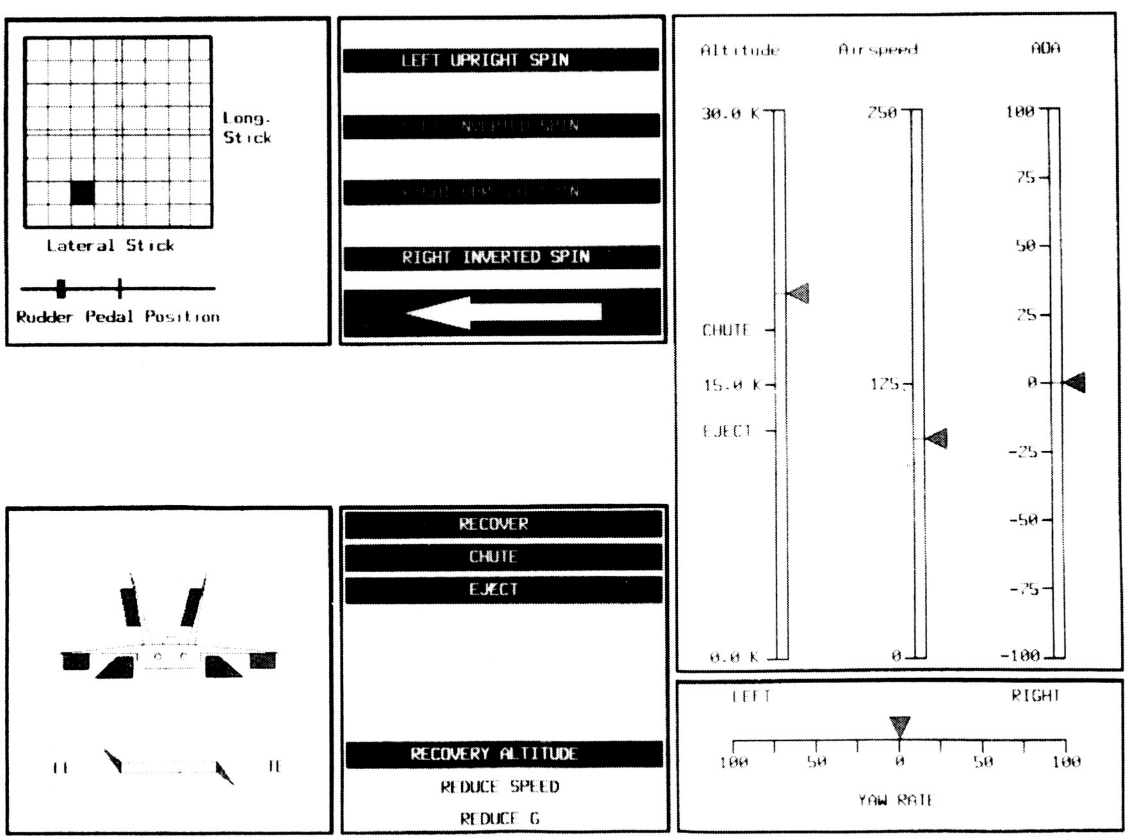

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Fig. 12 Spin alert display.

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