LA-UR 81-767

CONF-810314--53

MASTER

TITLE: THE FMIT FACILITY CONTROL SYSTEM

AUTHOR(S): R. M. Suyama, D. R. Machen, and J. A. Johnson

SUBMITTED TO: 1981 Particle Accelerator Conference, March 11-13, 1981, Washington, DC

LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545
An Affirmative Action/Equal Opportunity Employer

THE FMIT FACILITY CONTROL SYSTEM*

R. M. Suyama,** D. R. Machen, and J. A. Johnson
Accelerator Technology Division
Los Alamos National Laboratory, Los Alamos, New Mexico 87545

Summary

The control system for the Fusion Materials Irradiation Test (FMIT) Facility, under construction at Richland, Washington, uses current techniques in distributed processing to achieve responsiveness, maintainability and reliability. Developmental experience with the system on the FMIT Prototype Accelerator (FPA) being designed at the Los Alamos National Laboratory is described as a function of the system's design goals and details. The functional requirements of the FMIT control system dictated the use of a highly operator-responsive, display-oriented structure, using state-of-the-art console devices for man-machine communications. Further, current technology has allowed the movement of device-dependent tasks into the area traditionally occupied by remote input-output equipment; the system's dual central process computers communicate with remote communications nodes containing microcomputers that are architecturally similar to the top-level machines. The system has been designed to take advantage of commercially available hardware and software. The use of national and international standards in both hardware and software has minimized the design staff and maximized the flexibility and maintainability of the system.

Introduction

The FMIT facility will consist of a 100-mA, continuous-beam, deuteron accelerator and a flowing lithium target that will be used to produce 14-MeV neutrons for materials research,[1,2] and will be directed toward the development of containment materials for use in a controlled thermonuclear fusion reactor. The facility is being built at Richland, Washington, and will be operated by the Hanford Engineering Development Laboratory (HEDL). The FMIT accelerator design is being performed by the Accelerator Technology Division of the Los Alamos National Laboratory; a prototype of the front end of the accelerator is under construction at Los Alamos. The control system for both the FMIT and the FPA will provide the primary data acquisition, control and interface components that integrate all the individual systems into a functional facility.[3] The control system consists of a distributed computer network, control consoles and remote instrumentation.

Design Goals

The goal of the FMIT Control System is to provide a supervisory control structure through which the facility operators can monitor, tune, operate and shut down the accelerator, lithium target, experimenter and building utility systems from a central control area. The facility must operate for extended periods of time with only minimal operations staff. For this reason, information and control functions must be presented to the operator in an understandable and usable format. Color displays and computer-generated diagrams and graphs are used to solve the machine-to-man interface problem. Touch panels and software assignable control knobs are used to solve the man-to-machine interface problem areas most critical to accelerator tuning.

*Work performed under the auspices of the US Department of Energy.
**Hanford Engineering Development Laboratory employee working at the Los Alamos National Laboratory.

The overall requirement for the control console, and hence the supervisory control system, was to provide the operator with a "real-time" feel of the systems under control, and to relieve the operator of the tedious routine monitoring functions by reporting out-of-limits indications or significant parameter changes. Thus, a key design goal of the system was to provide the capability for an operator to request a control action from the console, to process and transmit the request over the computer network communication link, to perform the action, and to return a response within a "human response" time frame. A goal of four request-responses per second was established, based upon human-factors considerations and past experiences at other accelerator facilities. Note that at the same time that an operator requests a control action at the console, the system could be performing numerous other functions such as routine surveillance, closed loop control functions, and system logs.

In addition to meeting the technical control requirements, the facility control system also addresses a limited number of nontechnical design goals. First, because the final system will be operated and maintained by HEDL, but will initially be developed and operated by Los Alamos in support of the FPA, a key to the entire design was to minimize the development of specialized hardware and system and communications software. Thus the control system was designed to make the maximum use of existing vendor-supplied-and-supported hardware and software systems. Secondly, to make the maximum use of the prototype development effort, it was decided to make the prototype control system as prototypical as possible; thus, major portions of the prototype applications software will be directly usable on the final facility by expanding the data base and making only minor software modifications. This second goal led to the problem of limiting the larger facility equipment procurements to the same successful prototype equipment vendor. This problem was solved by combining the FMIT facility and FPA specifications for all major procurements and by adopting the international CAMAC standard for the process input and output system. Thus, we were assured that the successful vendors had the requisite capabilities to satisfy both FMIT and FPA requirements, and that multiple vendors were available to supply equipment consistent with the CAMAC standards.

Design Details

In accordance with our design goals, Digital Equipment Corporation's PDP-11 and LSI-11 line of equipment was selected by a competitive bidding process as having the necessary range of central processors operating under the same basic software operating system (RSX-11), and the associated hardware and software to satisfy our system requirements. Dual PDP-11/70s were bid for the FMIT central computer system with the capability to upgrade to VAXs if additional processing power is needed. Dual PDP-11/60s were procured as having the necessary power to meet the FPA central computer system requirements. Figure 1 shows the FPA control room and the two PDP-11/60 computers with their associated peripheral equipment.

The dual central computers are linked to each other, and to six (four for the FPA) LSI-11-based Instrumentation Subsystems, by intelligent communications controllers known as DMC-11s. These controllers

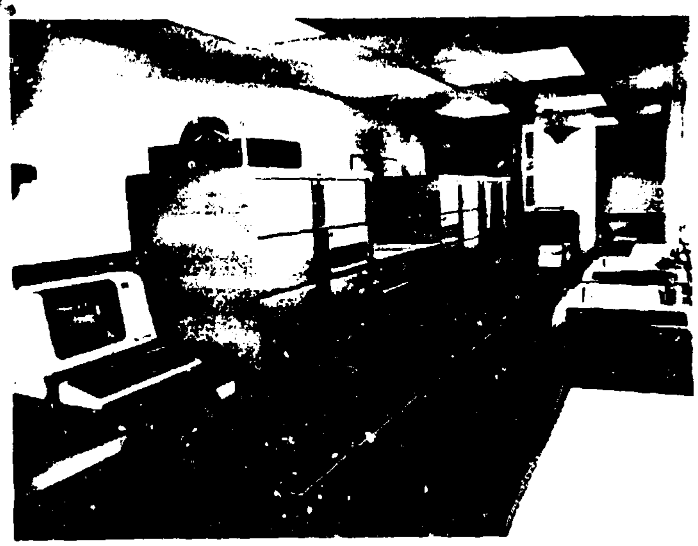

Fig. 1. FPA Control Room.

are a Unibus*-based device and are compatible with the central computers; to interface the DMC-11 and the associated computer network into the local Instrumentation Subsystem's LSI-11/23 microcomputer, a short section of Unibus and a Unibus-to-Q-bus* converter are necessary. The LSI-11/23 microcomputer is used as the Instrumentation Subsystem processor, which is physically located in a CAMAC Auxilliary Crate Controller (ACC) module. The use of LSI-11/23-based ACCs allows applications code to be developed, using the resources of the central computers and then downloaded through a fiber optic, bit-serial communications link for execution. The ACC allows the LSI-11/ 3 to access and control its own CAMAC dataway, as well as additional crates (by way of the CAMAC Serial Highway), in an extremely efficient manner. It will be possible to place additional processing capability in any CAMAC crate in an Instrumentation Subsystem. CAMAC interface modules are then wired to the various FMIT subsystems through a conventional cable plant and, where necessary, isolation instrumentation modules. Interlock and switching logical control for several FMIT subsystems is being provided by a Gould Programmable Controller. A block diagram of the FMIT control system is shown in Fig. 2, and Fig. 3 shows the Instrumentation Subsystem Assembly in the FPA injector control area.

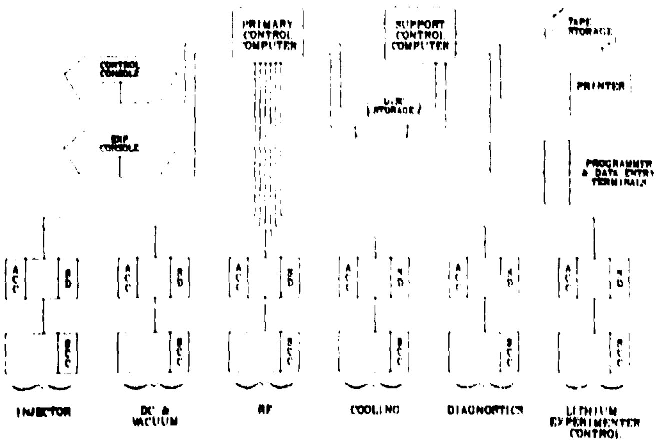

Fig. 2. Block diagram of the FMIT Control System.

*Digital Equipment Corporation bus structure

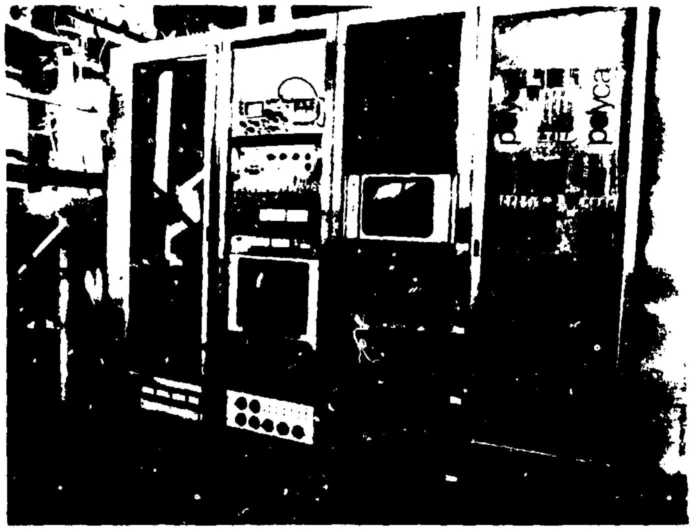

Fig. 3. FPA injection instrumentation subsystem.

The consoles for the FMIT and the FPA have been designed around graphic display devices and touch-sensitive panels for each display device. The FPA console is shown in Fig. 4, indicating the positioning of the various elements. The raster scan colorgraphic device (AED-512) is interfaced to the computer with a DMA channel so that display changing and updating take place in an acceptable time frame.

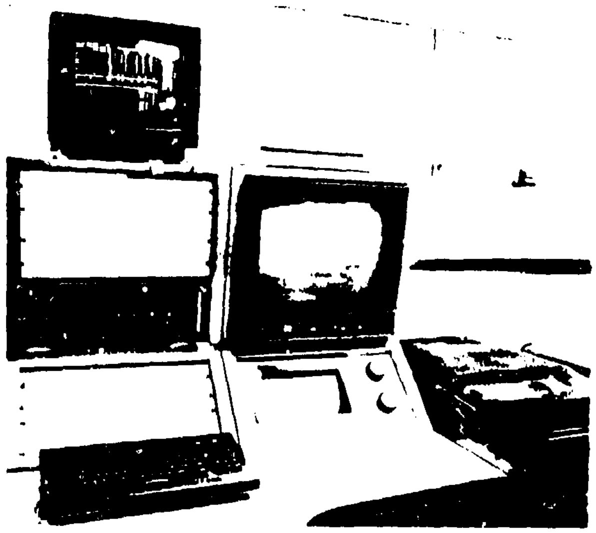

Fig. 4. FPA control console.

This device has an Elographics, Inc., touch panel for man-machine communications. Below the color display, a large alpha-numeric (23 cm x 30 cm) discharge panel with touch panel (Vue-Point, General Digital Corp.) is positioned, together with two software-assignable incremental shaft-encoder knobs. Overall process selection takes place on the color display, whereas the more detailed data feedback and control are accomplished on the knob and display panel. The center section of the console is reserved for analog communications and diagnostics.

Network Communications

In October 1980, a network communications evaluation was completed using the console, main computer system, and two prototype Instrumentation Subsystems. The results of this evaluation are reported below.

Network communications between the FPA central computers and the Instrumentation Subsystems are accomplished through the vendor-supplied and supported DECNET communications network software. Performance tests of DECNET, operating in the environment of the FPA control system, have measured the time required for a 256-byte message to be sent from a user task in the PDP-11/60 control computer to a user task in either the support PDP-11/60 or to an LSI-11/23 in an Instrumentation Subsystem, and back again over the communications network. Table 1 summarizes these performance test results for both DECNET and DLX; DLX is a subset of DECNET that provides only the line handler features. In addition, timing tests for round-trip messages between a PDP-11/60 and an LSI-11/23 were made at different line speeds and message sizes. These results are shown in Table 2.

TABLE 1

MESSAGE TIMES FOR ROUND TRIP SEND AND RECEIVE FOR A 256-BYTE MESSAGE

	PDP-11/60 to PDP-11/60 (1 Megabit/s link)	PDP-11/60 to LSI-11/23 (56 Kilobit/s link)
DECNET	45 ms	155 ms
DLX	17 ms	94 ms

TABLE 2

DECNET ROUND TRIP TRANSFER RATES

Message Bytes	60/60 (1 MB/s)	60/60 (56KB/s)	60/LSI(56KB/s)
40	39 ms	91 ms	91 ms
256	45 ms	-	156 ms
1000	71 ms	415 ms	418 ms

These timing results indicate that using a communications concept of one control message corresponding to one DECNET message would not be fast enough to satisfy the data communications requirements of either the FPA or the FMIT facilities. A packing technique was used to derandomize the message flow and to help increase the overall message transfer rate. This technique used a message handler at each end of the link to accumulate a number of short control messages into a DECNET message, which in turn was sent at a fixed rate. Thus, several control messages are sent in each DECNET message.

Several tasks were written to demonstrate the various control features needed on accelerator control systems. These include the periodic logging of a set of data channels, the display of data channels on the display CRT, the software connection of control knobs to command channels, and the plotting of the results of calculations based upon data acquired by the system. The results of these tests are subjective at best, but displays of channels connected to command channels can be updated at least 5 times per second. Data arrays of 100 points for plotting can be read, transported over the network, and plotted in 2 to 3 seconds. These times are obtained while other tasks are running and requesting data.

Tasks were written to load the PDP-11/60 control computer and to load the data communications network. A noticeable degradation in performance occurred only after the control computer was loaded to 75% of capacity or greater. The effect of message loading could not be noticed until the number of additional messages caused the 256-byte message packet to overflow. Two packets would then be sent when originally one had been sufficient.

Conclusions

At the time of this writing, the control room, main computers and console for the FPA have been installed and made operational. Instrumentation Subsystems for the injector, beam diagnostics and the prototype accelerator cooling system are in various stages of installation and checkout.

Installation and commissioning of the FPA control system will continue for the next year. The results of this effort will be directly applicable to the FMIT control system.

Acknowledgments

The authors would like to acknowledge the joint Hanford Engineering Development Laboratory/Los Alamos National Laboratory controls staff for their efforts in the design and and development of the FMIT and FPA Facility Control Systems.

References

1. R. A. Jameson, "High Intensity Deuteron Accelerator (FMIT)," IEEE Trans.on Nucl. Sci., NS-26 (3), pp. 2985-2991 (June 1979).

2. E. L. Kemp, D. D. Armstrong, J. O. Hartsell, D. J. Liska, and E. F. Parker, "Status Report on the Fusion Materials Irradiation Test Facility," this conference.

3. J. A. Johnson, D. R. Machen, and R. M. Suyama, "Distributed Control System for the FMIT," Proc. 1979 Linear Accelerator Conf., Sept. 11-13, 1979, Montauk, New York (Brookhaven Nat. Lab., Upton NY) BNL-51134, p. 279