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TA-55 Facility Control System Upgrade Project—Human-System Interface Functional Requirements

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TA-55 FACILITY CONTROL SYSTEM UPGRADE PROJECT—HUMAN-SYSTEM INTERFACE FUNCTIONAL REQUIREMENTS

by

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ABSTRACT

The functional requirements for that part of the Technical Area (TA)-55 Operations Center Upgrade Project that involves the human-system interface (HSI) are described in this document. The upgrade project seeks to replace completely the center's existing computerized data acquisition and display system, which consists of the field multiplexer units, Data General computer systems, and associated peripherals and software.

The upgrade project has two parts—the Facility Data Acquisition Interface System (FDAIS) and the HSI. The HSI comprises software and hardware to provide a high-level graphical operator interface to the data acquisition system, as well as data archiving, alarm annunciation, and logging.

The new system will be built with modern, commercially available components; it will improve reliability and maintainability, and it can be expanded for future needs.

I. BACKGROUND

The Technical Area (TA)-55 Plutonium Facility houses programmatic research and development activities involving the use of special nuclear materials. These activities are housed in building PF-4. The TA-55 Operations Center continuously monitors critical parameters associated with PF-4 operations to ensure that subsystems for such functions as ventilation and radiation monitoring are operating within acceptable limits.

The existing data acquisition and control system is approximately 17 years old and has become obsolete. Key hardware components are no longer manufactured, and replacements are unavailable. Besides being unacceptably difficult to maintain, the system cannot be expanded to any appreciable degree.

The first step in the system upgrade is completion of the Facility Data Acquisition Interface System (FDAIS). This step replaces the field multiplexer units (FMUs) which provide the interface between the plant instruments and the computer system. The replacement system is based on a set of programmable logic controllers (PLCs) and associated instrumentation. The PLCs will acquire data from the plant, perform most control functions, and communicate with each other as needed. This system will be reliable and robust for monitoring and limited control, but it is inadequate for operator interface needs.

The human-system interface (HSI) will fill the requirements for the operator interface. The system will primarily read data acquired by the PLCs and display them for the operator. It will perform such tasks as archiving data to disk, executing alarm limit comparisons, and annunciating alarm conditions. Many commercially available software packages can perform these services and are available for a wide variety of hardware platforms. These packages, typically called SCADA (supervisory control and data acquisition) systems or DCS (distributed control systems), are prevalent in manufacturing and other industries.

II. SYSTEM ARCHITECTURE

The system architecture will be similar to that shown in Fig. 1. The HSI will consist of a set of workstations and terminals that are networked through Ethernet. Each processor will run an operating system and the HSI applications software. The choice of workstation hardware is called the hardware platform; the choice of operating system is the software platform; and the choice of high-level software package is the HSI software.

The HSI must interface with the data acquisition system to communicate with the PLCs. The HSI will likely communicate with the PLCs directly by Ethernet, as well as by a separate data highway.

In addition to the architecture in Fig. 1 are components and cabling that implement redundant communications and operations.

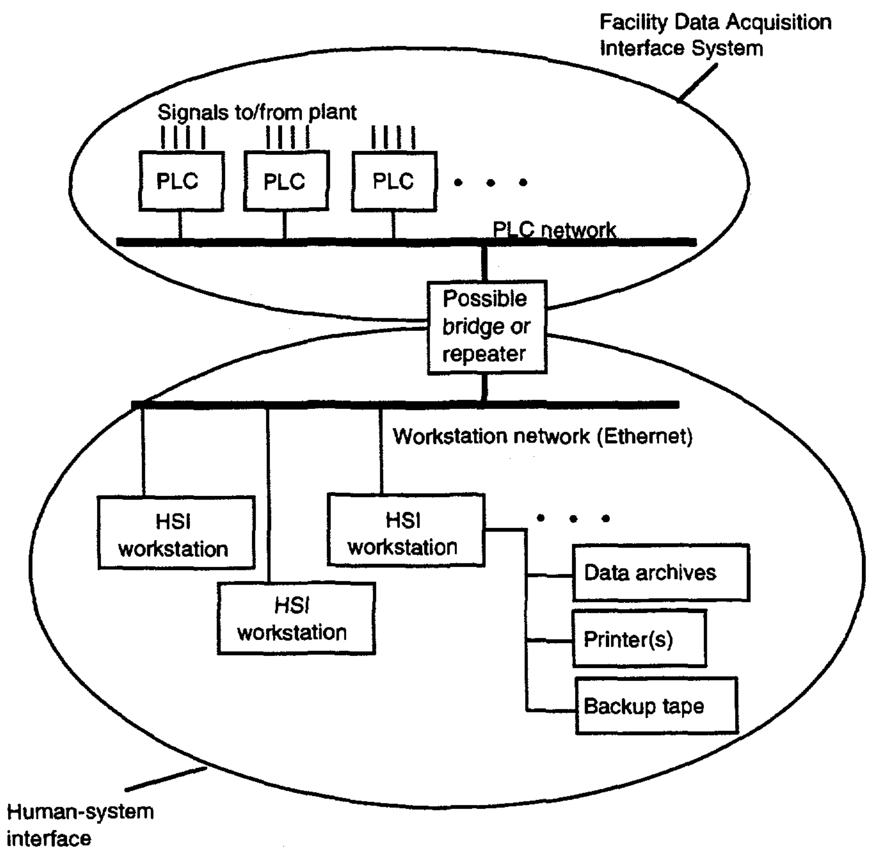

Fig. 1. Schematic of the system upgrade to the TA-55 Operation Center.

III. SYSTEM REQUIREMENTS

The fundamental requirements of the HSI include the following capabilities:

- adequate and reliable performance of all functions of the existing system;
- use of industry-standard modern hardware and software;
- adequate interface with the FDAIS; and
- allowance for adequate expansion.

In addition, primary hardware and software components must be commercially supported and easily maintained. Further hardware, software, and system specifications needed for accomplishing the fundamental requirements are discussed in Secs. IV–VIII.

IV. EXISTING SYSTEM FUNCTIONS

At a minimum, the new system must duplicate the functions of the present system. For most tasks, the new system must exceed the capabilities of the present system.

A. Graphic Process Display and Interaction

The primary means of plant monitoring is operator interaction with graphical displays that represent the plant processes. The necessary characteristics of system displays are as follows:

1. The HSI must display pixel-based color graphics as designed by the user. The graphics are to include dynamic symbols and objects that change values and attributes according to changing real-time data.
2. The HSI must support live displays simultaneously on at least 12 cathode-ray tubes (CRTs). Each CRT may have a different display, or the same display may appear on multiple CRTs. Each CRT must be capable of displaying up to four screens simultaneously in different windows.
3. If the same screen is displayed on multiple CRTs, or on multiple windows on a single CRT, a change made to one screen will be reflected on the others.
4. The HSI system must support development of at least 250 different screens.
5. All CRTs must have at least a 19-in. diagonal viewable area with a resolution of at least 640 pixels (horizontal) by 480 pixels (vertical) (standard very enhanced graphics adapter [VGA]). The HSI software must use this resolution.
6. The HSI graphic screens will support, at a minimum, these dynamic objects, which may be associated with real-time data:
   - numeric values as text, displayed in integer, floating point, exponential notation, hexadecimal, or binary formats;
   - bar graphs, strip charts (value versus time), x-y charts (value versus value);
   - slider/knob controls;
   - button controls;
   - numeric value controls;
   - text messages; and
   - various attributes of user-drawn objects.

   The following object attributes will be changeable according to real-time values:
   - size and position,
   - visibility,
   - blinking, and
   - color.
7. Operator control of dynamic objects will be primarily with the mouse and, where appropriate, the keyboard will be used, for example, to enter analog setpoints or operator comments. It must be possible to require operator verification of a change.
8. Navigation between screens must be possible by using the mouse.
9. Strip charts and x-y charts must allow the plotting of multiple real-time parameters on the same axes. Parameters are to be distinguishable by color. The user can distinguish parameters by color, modify axis scaling at run time, and autoscale the axes.
10. Users may calculate values in the HSI software by using real-time process values and various arithmetic operations, including addition, subtraction, multiplication, division, exponentiation, and logarithm.

11. It must be possible to import bit maps and other graphics produced by other graphic software programs into an HSI screen.
12. It must be possible to print graphic screens to a black and white laser printer that produces legible text and numeric value. It also must be possible to produce color prints of graphic screens that match the CRT screens and to produce a white-background hard copy from a black-background screen.
13. The HSI system will support password protection, either at the level of the HSI software or at the level of the operating system.

B. Data Archiving and Retrieval

The HSI will support the archiving of real-time data to disk. All data acquired from the PLCs or values calculated by the HSI will be eligible for real-time archiving. Also logged with the data will be time stamps, including the date and time to the second, and tag names. The log will reflect conditions for which the data are known to be invalid, for example, if communications with the PLC are broken. Further specifications include the following:

1. The HSI will include the capability to archive and store at least 20,000 different tags and to convert archived data into a text format suitable for importing into Microsoft Excel software.
2. The HSI will allow users to plot archived data. This feature will support multiple plots on the same time scale, allow the user to select the time scale, and function without requiring the archiving program to be halted or paused.
3. The HSI will log operator actions, along with time stamps and the operator's login identification.

C. Unlog Operation

The system must be able to accomplish the present "unlog" operation, which produces a daily log of all PLC input/output (I/O) point changes since the last unlog report. The report will include time, date, and a description of the state of the changed I/O point.

D. Alarm Management

The HSI must support operator notification of alarm conditions. The system administrator can configure alarms according to real-time values acquired from the PLCs or calculated by the HSI. Alarms will be generated by analog values exceeding high or low thresholds or by binary values in a certain state. Additional alarm management requirements are as follows:

1. Alarms will be logged to disk and to a dedicated printer.
2. The HSI must be able to display a screen showing all current alarms. This display is to be accessible from any HSI workstation.
3. The HSI will notify the operator of an alarm condition by a visual indicator on any of the process screens and, optionally, by an audible alarm.
4. The user will be able to distinguish at least two classes of alarms by both color on the screens and by sound.
5. It must be possible to enable and disable alarms at run time, either by operator command or by calculated values in the HSI.
6. It must be possible to set two alarms of the same type, but of different priorities, on the same analog parameter. For example, an increasing temperature could activate a "warning" alarm at one temperature and an "urgent" alarm at a higher temperature.

E. Performance Requirements

Required performance capabilities are as follows:

1. The HSI system will be capable of acquiring data from a single PLC at a rate of 2500 floating-point values and 7500 Boolean values per second. For this specification we will assume that there is no other network traffic.
2. The HSI will be capable of archiving up to 1000 floating-point values and 3000 Boolean values to disk per second, along with time stamps and tag names. This rate does not include the time to transfer data from the PLCs. The workstation performing this archiving is not required to perform any other HSI function.
3. An operator screen must be able to update 100 floating-point text values each second.
4. The HSI must be capable of updating strip charts and x-y charts at a user-definable rate from 1 point every second to 1 point every 10 minutes and of displaying up to six charts on a screen at one time.
5. The best-case time from a change in a PLC memory location to an associated operator screen update must not exceed 2 seconds. The worst-case time will not exceed 5 seconds.

F. System Test

A test of the HSI will be designed and executed jointly by project personnel and the vendor. The following performance data will be measured:

- uptime over a period of 1 week (any software or hardware problems or failures will be documented),
- time from a PLC memory change to an operator screen change, and
- archiving rates.

G. Human-System Interface Software Development

The HSI will support the following software development capabilities:

1. The HSI must include a capability for constructing graphic operator screens. This tool will be mouse/menu–based rather than program-based and support the following features:
   - static color graphics—lines, boxes, ovals, and text;
   - filled polygons and dashed lines;
   - grouping, moving, and resizing of objects and cutting and pasting of objects;
   - symbol libraries; and
   - multiple text fonts in sizes of at least 8–18 points.
2. It must be possible to develop HSI software on any of the HSI workstations. All workstations will access the software in a single location, so maintaining screens and databases, for example, in more than one location, will be unnecessary.
3. It must be possible to produce a report of HSI tag names and their associations with PLC addresses and tag names.

V. HARDWARE AND SOFTWARE PLATFORMS AND FEATURES

The particular requirements of the hardware and software platforms follow. The last two items are really design requirements. The justification is to ensure that the underlying hardware platform is mainstream and can support ancillary activities (for example, file transfers and X-windows) outside the HSI software.

1. The HSI software vendor must recommend and support all hardware and software necessary for operation of the HSI software.

2. The HSI must allow other programs to be run on a workstation simultaneously with the HSI software. Performance degradation is expected, but the HSI software must not be completely pre-empted.
3. The HSI system will support a backup system onto magnetic tape or other media with an expected shelf life of at least 10 years.
4. The HSI workstations will interconnect through Ethernet. The network protocol will not preclude the use of other protocols on the same network.
5. The HSI workstations and operating system must be capable of communicating by means of Transport Control Protocol/ Internet Protocol (TCP/IP).

VI. INTEGRATION WITH THE FACILITY DATA ACQUISITION INTERFACE SYSTEM

The FDAIS is based on Allen-Bradley PLC-5s and associated instrumentation. A number of PLCs will monitor plant parameters and perform certain control functions. The HSI simply communicates data between the PLCs and the operator. A reliable interface with the PLCs is essential.

1. The HSI will support real-time communications with Allen-Bradley PLC-5s and Allen-Bradley Small Logic Controllers (SLCs), read and write any of the data tables from the PLCs, and communicate with as many PLCs as Data Highway Plus (DH+) allows.
2. The HSI will support the use of user-defined alpha-numeric tag names for data communicated between the Allen-Bradley PLCs and other internal variables. These tag names will be at least 12 characters in length. At least 20,000 tags will be supported.
3. The HSI will be able to detect loss of communication with any PLC and notify the operator within 10 seconds.
4. A failure of the HSI must not cause *interruption* of PLC program execution or communication between PLCs. A failure of any PLC must not cause interruption of other HSI functions.

VII. SYSTEM EXPANSION

The system must be generally expandable to at lease twice the current system requirement to allow for future needs. The following list summarizes the full capacity of the HSI:

- 12 CRT screens active at once,
- 500 callable operator screens,
- 250 parameters per screen, and
- 20,000 parameters archived to disk.

The addition of PLCs, screens, HSI processors, archiving channels, or display channels will not require modification of existing software, tag names, or data tables.

VIII. MAINTENANCE AND SUPPORT

All hardware and software components necessary for HSI operation must be supported by their respective vendors for at least 10 years after purchase. For this reason, the software should support multiple platforms, for example, Windows NT, OS/2, HP-UNIX, and VMS, so that the hardware platform may be easily upgraded or changed in order to remain operable over an extended period (10 years). Software upgrades must be released on all the supported platforms at least yearly. Further maintenance and support requirements are as follows:

1. The HSI software vendor must offer regularly scheduled training classes.
2. The HSI software vendor must offer a maintenance agreement that ensures timely assistance with software problems.

3. The failure of any one HSI workstation must not require the facility control system to be shut down. More than one workstation must have the capability to perform any HSI function necessary for system operation (for example, archiving and alarming). It will be possible to switch these functions from a failing workstation in a timely manner. The worst-case time to repair any hardware failure must not exceed 48 hours.
4. Good-quality documentation must be provided for all hardware and software components.
5. The HSI software vendor must supply two references from buyers who use the software for a similar application.
6. The software should be configurable rather then programmable.

IX. CONCLUSION

We have outlined the functional requirements of the HSI software and hardware platform in this document. Our intent is is to provide clear criteria for the selection of software that will provide an adequate, up-to-date operator interface to the data acquisition system at the TA-55 Operations Center.