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CONSIDERATIONS ON NUCLEAR DATA LINK IMPLEMENTATION IN RELATION TO THE TECHNICAL SUPPORT CENTER, EMERGENCY OPERATIONS CENTER AND SAFETY PARAMETER DISPLAY SYSTEM

B. Stiefeld
D. Jeppensen

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Sandia National Laboratories
Albuquerque, New Mexico 87185
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ABSTRACT

Upon the occurrence of a significant event at a nuclear plant, both the Nuclear Regulatory Commission and the licensee must carry out certain roles to mitigate possible consequences. To accomplish their respective roles effectively, both require timely data from the plant instrumentation systems. The relationship of the NRC-oriented Nuclear Data Link to the individual licensee-oriented Technical Support Centers, Emergency Operations Facilities, and Safety Parameter Display Systems has been examined with regard to implementation of data acquisition, communication, and display requirements. The possible use of a common data acquisition processor for all four systems is discussed, along with technical considerations important in the implementation of such an approach. A common data acquisition system is not recommended but could be successfully implemented if tight control is exercised. Some of the anticipated difficulties in developing standardized data displays are outlined. Duplication at the NRC Operations Center of those displays available at the reactor sites will be extremely difficult unless industry-wide standardization of displays is implemented.

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I.

Introduction

In April 1980, Sandia National Laboratories reported the results of a conceptual design study of a system for acquiring and transmitting to the NRC Operations Center a limited but critical set of data from each nuclear power plant and for storing and displaying that data.[1] This system, known as the Nuclear Data Line (NDL), has been proposed by the NRC staff to augment and improve the response capabilities of the NRC during incidents and accidents. The NDL is perceived as a significant element in the larger task of upgrading emergency response capabilities. However, because of lack of detailed definition on the other proposed emergency response facilities, their interaction with the NDL was not investigated in depth.

In the interim the NRC has defined in more detail the functional criteria of three other emergency response facilities[2]:

- Technical Support Center (TSC)
- Emergency Operations Facility (EOF)
- Safety Parameter Display System (SPDS)

Additionally, in a series of meetings conducted by the NRC on June 2nd and 3rd, 1980, it was agreed that the minimum data requirements for the NDL, TSC, SPDS, and EOF would be incorporated into RG 1.97.[3] Licensees may elect to provide the TSC, EOF and SPDS with additional data. However, the NRC will not require information beyond that listed in an updated version of RG 1.97 with the possible exception of a limited number of event initiation signals required for the NDL.

The additional functional definitions for the TSC, EOF, and SPDS, provided by Ref. 2, and specification of RG 1.97 as a minimum data base for these three response centers have provided the foundation for the present evaluation of the interrelationship between the NDL and the other response facilities. Section II of this report deals with the functional relationships between the response facilities, while Section III explores the influence the TSC, EOF, and SPDS may have on NDL site hardware approaches and on the NRC Operations Center displays. Section IV covers cost considerations related to implementation alternatives and, finally, conclusions and recommendations concerning NDL implementation as influenced by the other response centers are summarized in Section V.

II.

Functional Interrelations Among the Four Emergency Response Systems

The Nuclear Data Link

"In the event of an emergency involving a licensed nuclear power reactor, the NRC must independently assess the seriousness of the event and its potential consequences to health and safety of the public. Actions by state and federal governments to support the licensee in limiting the consequences of such an emergency will, in part, be based on this assessment. To perform this function, NRC must have prompt, accurate information on the status of the reactor, on the quantities of radioactivity released and on site weather conditions."[4] It is the primary purpose of the proposed NDL system to serve as the source for this technical information from each nuclear power reactor.

Figure 1 presents a conceptual overview of the NDL, as described in Reference 1. The NDL system consists of three major subsystems, two of which--the data acquisition subsystem and communication subsystem--are national in scope in that they are physically located at each of the licensed reactor sites. The third subsystem, the NRC Operations Center, potentially must deal with data from any of the licensed nuclear power sites.

The NDL data acquisition subsystem will be a licensee responsibility and will interface directly to transducer inputs at the licensee's plant. It will have the capability for accepting at least 100 different

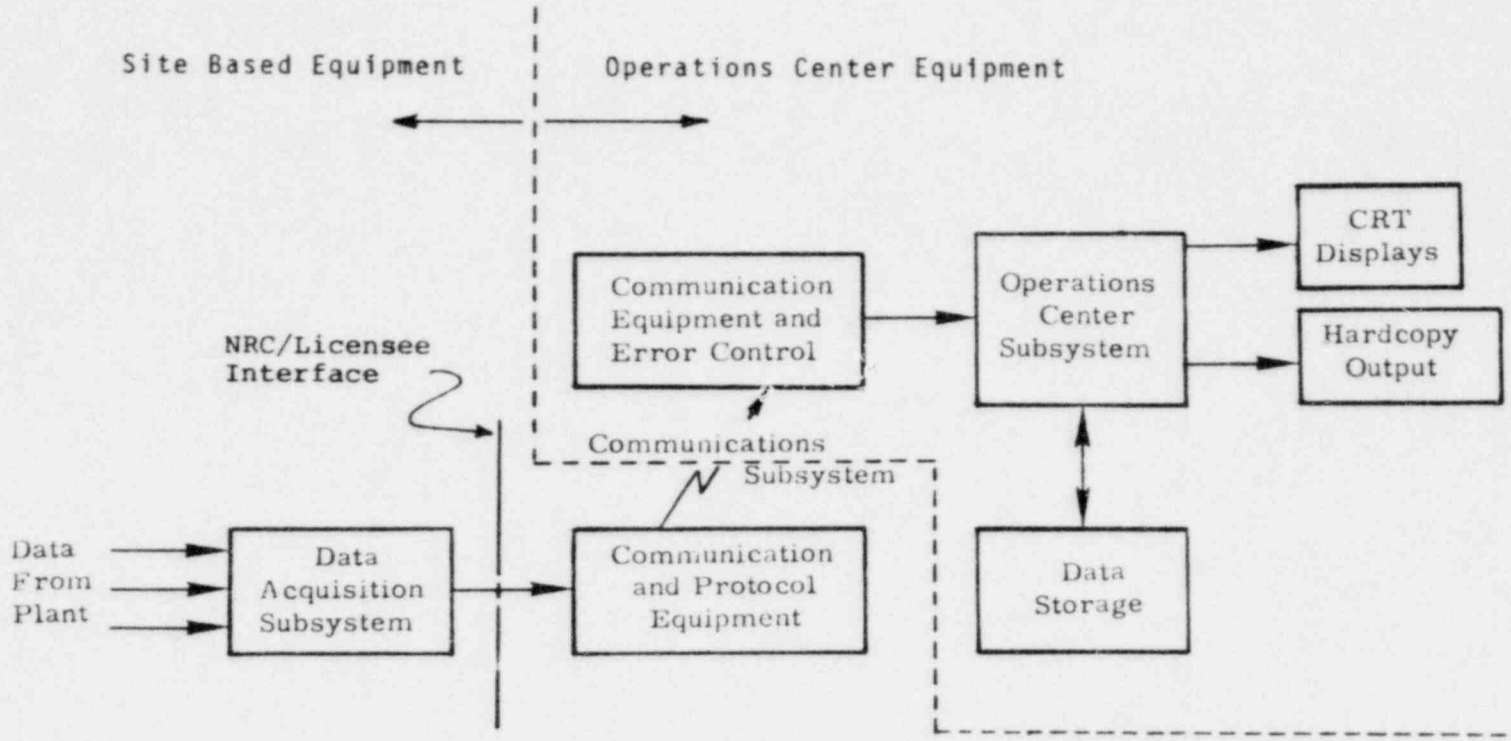

Figure 1. NDL Conceptual Overview

parameter values each minute, including several transient monitor values, and event alert signals. This data will be transmitted, in a format which is standard for all sites, to a locally installed NRC terminal (formerly called the Site Transmission Unit).

The NRC terminal is the site interface to the NDL communications subsystem. It will accept data from the data acquisition subsystem, perform error checking, respond to retransmission requests, and format data for transmission to the Operations Center. It will provide a remote system test and verification capability to detect and isolate system problems. Communications control equipment will receive data at the NRC Operations Center in Bethesda, Md. The entire communications subsystem will operate using a high-level data transmission protocol executing in the communications controllers at both ends of the link.

The third subsystem, the NRC Operations Center, will provide the man/machine interface for the NDL. Data received from the communications subsystem will be decoded and placed in a data base structure on mass storage within the Operations Center computer system. This data will be available via CRT display or line printer for analysis during an incident at any reactor site. Both discrete time values and time trends of the parameter values will be accessible. Interactive and slave CRT monitors will be available for use by the NRC staff in its incident analysis and response activities. The Operations Center computer mass storage system will have the capability to store two weeks of incident data from any reactor site.

The NDL system will automatically save the latest 30 minutes of data from every site. Automatic alert detection will also be accomplished,

based upon composite values of a subset of critical parameters. Whether these two functions will be accomplished at the Operations Center or at each site has not yet been decided.

The Technical Support Center*

The onsite TSC is a required emergency response facility that will alleviate control room overcrowding during an accident. It will provide plant management and technical support to reactor operations personnel during emergency conditions and during emergency recovery operations. Comprehensive data to monitor the reactor systems status and evaluate plant systems abnormalities will be provided in the TSC. These will include current value, time rate of change, and time history displays of critical operational parameters. Sufficient data to determine the plant dynamic behavior prior to and throughout the course of an accident will be available for analysis in the TSC. TSC personnel will have ready access to up-to-date plant records and procedures to support technical analysis and evaluation of plant conditions during the emergency and recovery operations.

The TSC will be the emergency operations work area for designated senior plant management personnel, designated licensee engineering and technical personnel, a small staff of NRC personnel, and any other licensee designated personnel needed to provide the required technical support. The location of the TSC will be outside but in proximity to the control room to allow "face-to-face" interaction between control room personnel and plant management working in the TSC.

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*Abbreviated functional descriptions of the TSC, EOF, and SPDS have been excerpted from Reference 2, as developed by the NRC's Safety Data Integration Group.

The Emergency Operations Facility*

The near-site EOF is a required emergency response facility located near the reactor that will provide continuous coordination and evaluation of all licensee activities during an emergency having or potentially having environmental consequences. The overall management of licensee resources in response to an emergency will be based in the EOF. The EOF will function as the post-accident recovery management center for both onsite and offsite activities. To accomplish these functions, capability will be provided in the EOF for the collection and evaluation of all pertinent radiological, meteorological, and geophysical data.

The EOF staff will coordinate the licensee's emergency response activities with those of local, State, and Federal emergency response organizations, including the NRC and FEMA; and will provide current information on conditions that may potentially affect the public welfare.

The location of the EOF will be at a distance such that habitability can be maintained during an incident, but in close enough proximity to assure effective communications and response control at the facility.

The Safety Parameter Display System*

The SPDS is a required operating aid that will display to the control room personnel those variables that define the safety status of important plant systems. The SPDS will be solely a monitoring system, not intended to replace any existing control room displays. Its purpose will be to

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*Abbreviated functional descriptions of the TSC, EOF, and SPDS have been excerpted from Reference 2, as developed by the NRC's Safety Data Integration Group.

consolidate information that describes plant safety status and to present this information in a useful display format. The system will be operable, along with the other plant safety systems, during normal and abnormal operating conditions.

The design of the SPDS will provide real time display in the control room of a minimum set of plant parameters from which the safety status of the plant may be quickly evaluated. It will be capable of displaying this information during both steady state and transient conditions and will provide early indication of situations where process limits are being approached or exceeded. Magnitudes and trends of appropriate parameters will be accessible to allow quick assessment of important plant processes. The SPDS will be located in the plant control room and will require no additional staffing beyond current levels.

Interrelations

A summary of the features of each of the four emergency response facilities, based on the requirements given in Ref. 2, is presented in Table I. Examination of this summary shows that the greatest commonality lies in the area of minimum data requirements. This generalization can, however, be somewhat misleading in that licensees may add to the minimum list additional data they feel is needed to properly implement the SPDS, TSC and EOF.

TABLE 1

SUMMARY OF NRC REQUIREMENTS FOR EMERGENCY RESPONSE FACILITIES

SYSTEM	Location	Time of Operation	Prime Users	Minimum Data Requirements	Primary Functions
SPDS	Control Rm.	Continuous	Reactor Operators	Subset of Data Specifically Listed in RG 1.97*	-Monitor safety status of important plant systems -Display overall safety status -Provide alert signal if any safety parameter approaches an unsafe condition
TSC	Near Control Room	During Emergency & Recovery Operations	Licensee Mgt. & Technical Support Staff/NRC Site Team	All Data Specifically Listed in RG 1.97* plus site-specific Type A data Duplicate SPDS Displays	-Plant mgt. & tech. support for control room -Info source for EOF & NRC -EOF functions until EOF is staffed
EOF	Near Reactor (1-3 miles)	During Emergency & Recovery Operations	Licensee Mgt. & Technical Support Staff/NRC Site Team	All Data Specifically Listed in RG 1.97* plus site-specific Type A data Duplicate SPDS Displays	-Overall mgt. of licensee emergency response resources -Coordinate & evaluate actions having potential environmental impact -Coordinate with local, state & federal agencies -Public information
NDL	Nationwide	Continuous	NRC Executive Mgt. Team & Tech. Staff	Subset of Data Specifically Listed in RG 1.97*	-Independent Assessment -Assist licensee -Review & approve certain proposed licensee actions -Be prepared to direct certain actions -Provide information

*Those variables which are exclusively type A, and therefore not specifically listed in RG 1.97, are not to be handled by a common data acquisition processor.

The SPDS, TSC and EOF are site-oriented and functionally intended to aid the licensee in carrying out his emergency responsibilities. The NDL, in contrast, is nationwide in scope and is primarily intended to aid the NRC in executing its responsibilities.

The SPDS and the NDL operate continuously; whereas, the TSC and EOF are placed into operation only during emergencies. Therefore, the SPDS and NDL will be prime sources of information during the early portion of an emergency for the licensee and the NRC, respectively. At later times the licensee and NRC can draw on the resources available at the TSC and EOF.

Of the four response facilities, the TSC and EOF are the most similar. They are both site-oriented, though located outside the reactor control rooms. They are activated during the same levels of emergency action; however, the number, type and level of staffing may vary according to the emergency. They both require live operational plant data, current meteorological and radiological data, and plant records, drawings, and procedures. Both require protection from radiation, environmental hazards and acts of God; and they require backup facilities. The TSC and EOF must have voice link communication with all other facilities. Both must have provision for occupancy by NRC personnel.

At a summary level, there is considerable commonality between the TSC and EOF. The TSC, however, is oriented more toward plant operational

safety; whereas, the EOF functions lean toward the assessment of, and response to, potential or actual radiation releases; coordination of protective measures; and management of the overall licensee response.

All of the facilities are required by the NRC to acquire and display as a minimum all, or subsets of, the common data set listed within Revision 2 of RG 1.97. This data is to be acquired through one or more data acquisition processors, independently from the plant process computer. All four facilities require data display capabilities that show current values, historical trending, and time rate of change during both steady state and dynamic conditions prior to and throughout the course of an accident. All the facilities must maintain a high level of interaction during an accident.

From this brief discussion, it can be seen that the greatest potential for interaction between the three site-oriented facilities and the NDL is in the area of data acquisition and display. Commonality in data acquisition has the potential of reducing cost but may reduce reliability if not properly implemented and controlled. Commonality in displays can enhance communications between facilities but can be extremely difficult to implement in the NRC Operations Center unless there is industry-wide standardization. These two topics are discussed in detail in the next section.

III.

Influence of TSC, EOF, and SPDS on NDL Implementation

The implementation of the three site-oriented response facilities is most likely to affect the NDL in the areas of: 1) site-based hardware, and 2) display definitions at the Operations Center. The site-based hardware considerations are multi-faceted, as will be shown.

Implementation of the SPDS, within the control room area, will have an effect on the NDL system only from the aspect of display commonality. Implementation of the TSC and EOF, exterior to the control room, does impose the additional burden of transmitting the required data set from the control room or some related area to the TSC and EOF areas. Requirements for the techniques to be used for this data transmission are not explicitly defined at this time. If the licensee chooses to use non-computer-based methods (TV cameras with recording capabilities or analog channels are possible examples), the effect on the NDL as outlined in Ref. 1 will be insignificant. However, the draft requirements of Ref. 2 imply that modern digital techniques and the analytic software and methods of computer-based data processing will be necessary.

Given this, a single, dedicated, stand-alone data acquisition system serving the needs of these three site-response centers, and of the NDL appears desirable from an overall cost standpoint. Recognition of the

overlapping of data sets and monitor functions implies that a common system may be employed to acquire data for the TSC, EOF, SPDS, and NDL, as long as the data will be acquired in timeframes that meet the requirements of the NDL specification in Appendix A of Reference 1, and as long as the design and implementation of such a common system does not allow the integrity of the NDL data stream to be corrupted by separate requirements imposed on the TSC, EOF, and SPDS.

It is the opinion of Sandia that the NDL would best be implemented as a completely separate system with a dedicated NDL data acquisition processor as described in Ref. 1. This would preclude the probable introduction of error sources into the NDL system by future maintenance and enhancement activities to support the TSC, EOF, and SPDS systems. A common data acquisition processor approach could also result in a reliable NDL system provided that tight control is maintained over implementation of the limited set of variables specifically listed in RG 1.97*; and, further, that tight control is maintained over any future proposed changes to this data set. If a common data acquisition processor is used, it must be solely for the purpose of acquiring and transmitting one complete and invariant data stream to the SPDS, TSC, EOF, and NDL terminal. The format of this invariant data stream must be as specified for the NDL. Long distance data transmission, computer networking, and interactive capabilities will not be provided by this processor.

It is our understanding that the variables listed in the final revised RG 1.97 will satisfy the NRC requirements for data availability

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*Those variables which are exclusively type A. and therefore not specifically listed in RG 1.97, are not to be handled by a common data acquisition processor.

in the NDL, TSC, EOF and SPDS systems. This, however, does not and should not preclude individual licensees from augmenting these data with additional variables to meet their unique requirements for the TSC, EOF, and SPDS systems. It is our position, however, that if a licensee chooses to include additional variables in these systems, that they be included using a data acquisition processor other than that used for acquiring the RG 1.97 listed data.

Figure 2 presents a functional schematic of an integrated data acquisition approach that should meet the requirements of the NDL; provided that the above caveats are observed.

The nationwide scope of the NDL does impose a standardization burden not found in implementation of the site-oriented SPDS, TSC, and EOF systems. As an example, site-oriented designers, to reduce conversion problems and increase transmission speed, might normally transmit data to the TSC in some unique binary code or perhaps use the internal binary code of their particular computer systems. Dealing with such a data stream on a local level is straightforward; however, dealing with a large number of different data streams at the NRC Operations Center is an extremely difficult, if not impossible, task. As pointed out in the NDL Baseline Design[1], the licensee should, therefore, be responsible for providing NDL data using a standardized format specified by the NRC. This standard will be based on the simple and widely used ASCII code and EIA RS-232-C interface.

In our view, no aspect of the TSC, SPDS, or EOF affects communication protocol and error/flow-control problems. The communication network requirements for a standard high-level protocol, self-test capability, error

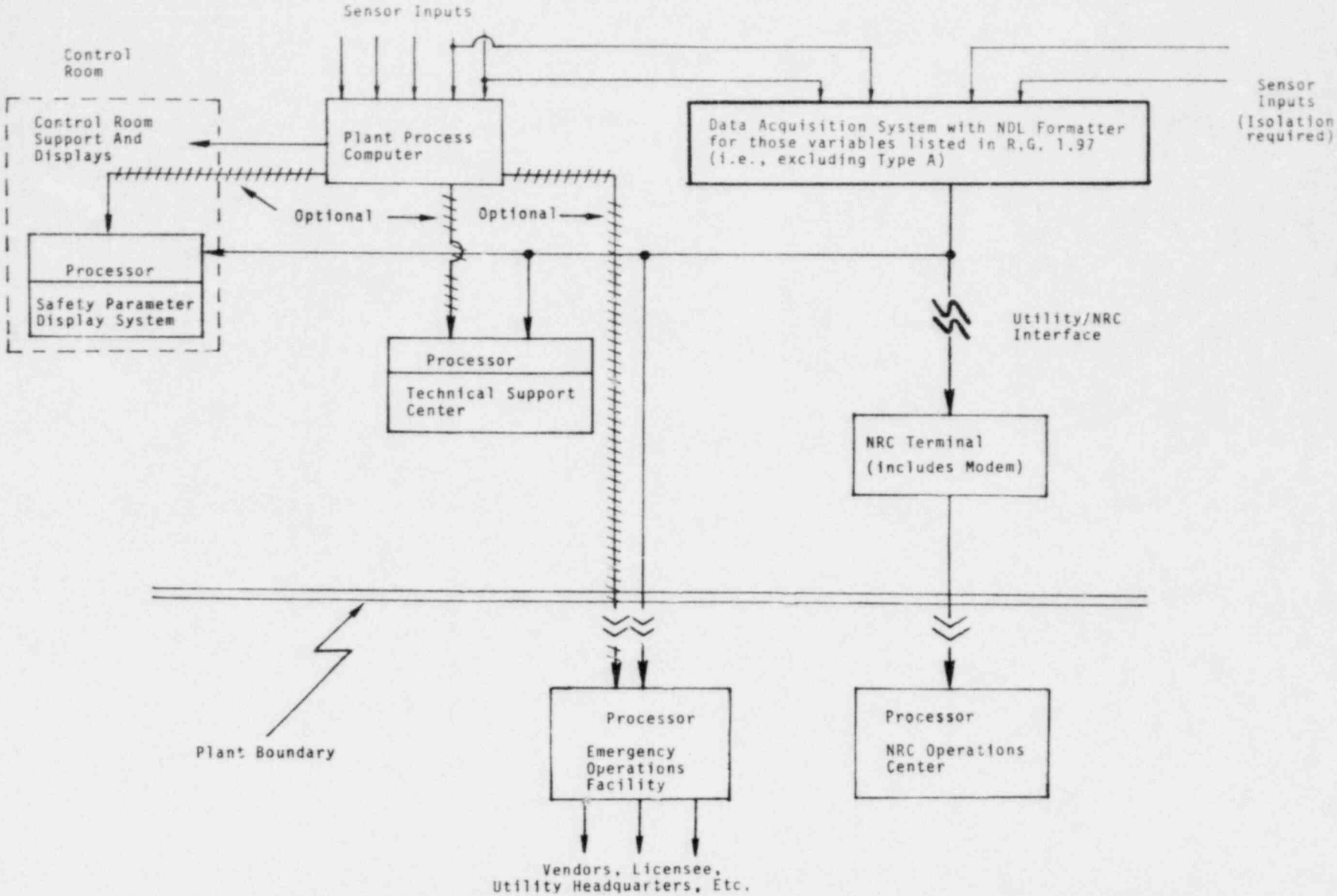

Figure 2. Functional Block Diagram of Data Flow Using a Common Data Acquisition System

checking and retransmission, and design flexibility are best met by use of a common nationwide design. Our previous recommendation that the NRC provide a site transmission unit (or NRC terminal) to perform these functions remains unchanged.

Reliability of the data acquisition system shown in Figure 2 is critical to the performance of the emergency response centers. Failure of this system during an emergency could seriously limit the capability of all the emergency response centers. Depending on the technique used for implementation, there exists the possibility that some failure modes might propagate backwards to the common transducer inputs, thereby destroying a signal to all response centers. In the past, care has been exercised to insure the adequacy of the isolation features for the safety grade transducer signals. When considering the situation where a common transducer input would be furnishing information to all response centers, as is the likely situation, isolation circuits and high reliability multiplex units should be considered for those signals which, while not designated safety grade, provide significant information on the state of the reactor. Redundant multiplexing with passive isolation circuits should be considered. In any case, reliability in this critical data acquisition area must be emphasized.

The second area that will influence the NDL development involves commonality of displays. The data variables available at the NRC Operations Center will be a subset of those variables at the site; indeed the site has all the data that will be available at the Operations Center. Theoretically, it would therefore be possible to have the same displays at both locations. At present, there is no specific requirement

that displays at the control room and its associated TSC be exactly the same; there should, however, be a great deal of commonality. There is also no requirement that displays at TSCs located at different reactors, operated by the same or different utilities, be common. Unless a method is found to standardize the displays at the numerous TSC locations, it will be impossible for the NDL Operations Center to duplicate displays found at each site.

If there is an opportunity for standardization of displays in the near term, it may lie in the area of the SPDS. The view of the SPDS as a safety related display presents the possibility that an industry consensus on the SPDS formats could reasonably be reached for the various reactor types. Such a limited number of display formats, reasonably constant in structure, could be implemented on the NDL, as well as at each control room if generic display equipment with equivalent formatting capability is used at each site. Similarly, if consensus could be reached on some key display formats in the TSCs, these displays might also be standard from site to site. If desired, the two-way communications feature of the NDL might be employed to download ASCII coded data streams from the NRC Operations Center to each site. Such data streams could represent printed or graphic output for specified types of display devices.

These discussions of display commonality are not intended to imply that there will be no other communications between the NDL Operations Center and the site-response groups. The existing voice link will be maintained and should be expanded to include the TSC and EOF centers. Telefax and voice can be used to provide consultations and supplementary information. The NDL with its automatic data acquisition and analytic capability will form only the baseline for the NRC response; but similarity of displays could certainly expedite the communication process.

IV.

Cost Considerations as Related to Implementation Alternatives

In the report "Update on Staff Actions Regarding a Nuclear Data Link"[4], four implementation alternatives are discussed:

1. Sandia concept described in its Baseline Design
2. Sandia concept as modified by TSC, EOF, and SPDS implementation
3. Line Printer and minimal graphics at the NDL Operations Center driven by the TSC and EOF
4. Line Printer only at the Operations Center driven by the TSC and EOF

Alternatives 3 and 4 above do not meet the technical specifications given Sandia as a basis for its conceptual studies and cost estimates. These alternatives are deficient in meeting requirements regarding Operations Center display systems, data recall, pre-event and event data storage, transmission speed, transient acquisition, data reliability, etc. Because of these deficiencies, Sandia evaluated and discarded these alternatives.

Alternative 2 is based on the NRC staff's preliminary view of the influence of the TSC and EOF implementation on Sandia's Baseline Design. Alternative 2 assumed that the processor capabilities of the TSC and EOF would eliminate the need for a dedicated NDL data acquisition processor and that the NDL site transmission unit would be provided by the licensee, resulting in a corresponding decrease in NRC costs.

In actuality, the potential cost savings lie only in the possibility of combining the NDL data acquisition processor with that for the TSC, EOF and SPDS. This cost savings would accrue to the licensee. The site transmission unit (or NRC terminal) must, as previously discussed, still be provided and maintained by the NRC to assure the integrity of the NDL network communications system.

Co-implementation of the NDL, TSC, EOF, and SPDS data acquisition systems therefore does not affect the NRC costs, and Alternatives 1 and 2 are roughly equivalent. The NRC costs for implementation of the NDL, as summarized in Ref. 4 ($17.2 million plus operations and maintenance costs of $4.3 million through the first full year of operation) are still applicable.

V.

Closure

From a reliability standpoint, Sandia would prefer a completely separate data acquisition system dedicated to the NDL, to preclude any detrimental effects of future modifications to support non-NDL requirements. However, the large number of common required data variables between the NDL, TSC, EOF, and SPDS, makes consideration of a co-implemented data acquisition system appear reasonable from a cost standpoint. Such an approach should also result in a reliable NDL design provided that: 1) the data acquired is limited to that listed specifically in the final RG 1.97 Revision 2; 2) any proposed modifications to this data list are strictly controlled; 3) one complete and invariant data stream is supplied to all centers; and 4) long distance data transmission, computer networking and interactive capabilities are not handled by a common data acquisition processor.

Several NDL implementation alternatives have been discussed by the NRC in previous documents. The co-implementation option could result in a cost savings to the licensee, but because this option results in even stronger rationale for a site transmission unit (NRC terminal), no cost savings would be realized by the NRC.

Should the co-implementation option be exercised, the impact of the TSC, EOF, and SPDS systems on the NDL would be primarily in the area of

site-based hardware design. Secondary considerations of site and Operations Center display format equivalence would be the same regardless of whether a common data acquisition system is used.

The data acquisition hardware and associated signal conditioning, isolation, and multiplexing circuitry are critical from an NDL reliability standpoint. This situation would be amplified by the co-implementation option and calls for the licensee to exercise great care in data acquisition system design and implementation.

In the co-implementation approach, the data stream will pass through the NDL formatter in the data acquisition processor, where it will be conditioned and converted to engineering units. The digitized data stream will then be transferred to the NRC terminal unit in conformance with an NRC specification, standard for all sites, based upon ASCII code and an EIA RS-232-C interface. This data stream must be received directly from the NDL formatter and must not depend upon the TSC, EOF, or SPDS processors. Further, no NDL data should be drawn from the plant process computer. It is an important consideration that the NDL data not be extracted from any special purpose computer other than the dedicated data acquisition processor. When more than one set of interests are represented in a real-time computer systems, it is difficult, if not impossible, to protect all interests in the face of inevitable conflicts, modifications and enhancements.

When the NRC terminal receives the data stream, it will perform the functions of:

- providing a standard high-level protocol envelope around the transmitted data records

- responding to Operations Center data error and retransmission signals
- providing standard hardware error and state of health signals that enable automatic testing of the complete NRC system to the NRC/Licensee interface
- allowing a certain minimal design flexibility for the NDL system

With the co-implementation option, it is anticipated that the NDL formatter, because of possible conflict with the other systems data access requirements, might require more extensive error checking to assure its proper operation. The NRC terminal will aid in providing this checking function.

The minimum TSC, EOF, NDL and SPDS data sets required by the NRC will all be subsets of the data variables specified in RG 1.97. All data available to the NRC Operations Center are then by definition available to the TSC, EOF, and SPDS. However, because of a lack of site-to-site uniformity in display formats, it is impractical to expect the NRC Operations Center displays to match any one set of site displays. An exception might evolve with development of the SPDS displays, or another key group of displays, if an industry consensus can be reached concerning display formats and equipment.

Consultation between the NDL and the sites can be carried out over the existing phone links with the common data serving as the technical baseline for any discussion.

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