REVIEW OF THE PROPOSED

NUCLEAR DATA LINK

11/18/80

DATA SYSTEMS BRANCH
COMMUNICATIONS DIVISION
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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1.0 SUMMARY

1.1 REQUIREMENTS

The requirements and technical specifications for the Nuclear Data Link (NDL) are not adequately documented, resulting in several proposed system features which are not traceable to particular requirements. Therefore, a detailed requirements document should be developed immediately to serve as a basis for technical specifications which will drive the system design.

We recognize that, for a new system like the NDL, it may not be possible to cover all requirements with the same level of detail, and that new requirements may in fact evolve with operational experience. But, as currently stated, several specifications can be misinterpreted and there is potential for large cost and/or schedule overruns.

1.2 OVERALL SYSTEM CONCEPT

We recommend the centralized "Standard Data Acquisition System" approach over the distributed "Stand-Alone Data Acquisition System" approach. There are several technical and management advantages to the Standard Approach in addition to the logistics advantages presented by the Research Triangle Institute in their review of the NDL.

1.3 SYSTEMS APPROACH

We feel that there are numerous systems-level considerations which should be addressed. For example, we recommend that the NDL be implemented in two phases: an initial "Pilot Phase" involving about 5 sites would serve to demonstrate and validate the NDL concept; this phase would be followed by an "Operations Phase" which would extend the NDL to all 80 sites. As another example, we recommend that a single software team have responsibility for all software development for the NDL. These and other considerations are presented in Section 3.

1.4 OTHER DESIGN CONSIDERATIONS

We recommend that additional design considerations be evaluated and costed, such as:

- capability for the NDL to perform self-testing at regular intervals
- capability for the system to handle two, not just one, concurrent incidents
- installation of identical Site Terminal Units (STU) throughout the NDL

1.5 COST

We feel that Sandia's cost estimate of $20 million is not unreasonable, although the specifications in Appendix A of Sandia's "Conceptual and Programmatic Framework for the Proposed Nuclear Data Link" lack sufficient detail to explain the implementation as described. We recommend that:

- the costs be revised, using more detailed requirements and specifications
- the costs for new suggestions from this report be included
- the costing exercise include total system lifetime costs for 5, 10 and 20 years

2.0 REQUIREMENTS

A detailed requirements document should be developed immediately in order to derive more precise specifications which can drive the systems design. As presented, some specifications can be misinterpreted, have large potential for cost/schedule overruns, and cannot be validated as requirements.

This looseness is especially noticeable in the areas of software requirements (display formats, command language for operators, etc.) and technical/management interfaces between licensees and the NDL.

2.1 EXAMPLES OF INSUFFICIENT REQUIREMENTS. In several areas the functional requirements are not stated in sufficient detail to drive system design; hence, the stated design is not traceable to a requirement. The result could be systems implementations which are more powerful and/or costly than anticipated. For example:

a. In Section 6 of the Specification, there is no indication of how many parameters are to be displayed on the CRT screen at one time, how they are to be formatted (i.e., which subset of the 150 or so readings), or how data from a particular site can be selected by the NRC staff.

b. In Section 6.2, there is no specification for graphical resolution (e.g., 1024 raster points per line), no mention of which colors nor color intensity, no mention of screen size, no mention of how the displays can be selected, colors assigned, or hardcopy output requested.

c. In Section 7, there is no specification describing how the data is to be stored on mass storage for subsequent post-event analysis; implication is that all data will be stored as ASCII coded engineering values and accessed/processed using capabilities provided by commercially available management information systems.

d. Even though the NDL implementation involves considerable software development, there is hardly any mention of software development methodology, processing functions, operator command language, display screen formats, methods for data storage/retrieval, data base backup procedures, data loss (e.g., during system downtime), checkpoint/restart procedures, software maintenance and configuration control (e.g., fixing software bugs and distributing corrected software with matching documentation), and software documentation.

?. Time tag should be specified as Universal Time Code, and included as part of the interface requirement for the licensees.

2.2 EXAMPLES OF UNTRACEABLE IMPLEMENTATIONS. Several proposed solutions to a requirement are stated without traceability. For example:

a. in the Baseline Design, "Data handling and soft ·e require a CPU of the supermini class..." No rationa was given to substantiate this remark, and in fact we believe that a PDP-11/44 mini could do the job. There is also no justification for "32-bit word length unit supporting 2 megabytes of core memory"; data could be in binary form, and many programs operate within 32 Kbytes of memory on PDP-11/xx computers.

b. the statement "Data-base-generation is the key element in assuring the smooth functioning of the Operations Center" should be stated only after the functions of the Operations Center have been delineated. Since the VAX does not have data base management system software, this can be a very costly item to develop and maintain (i.e., may require a data base administrator with staff). More significant, there is no explicit requirement for a data base system.

c. Reasons should be given for purchasing "standard software packages"; what are the packages, why are they needed, how they will be used, etc.

d. There is no explanation of how the 6 console terminals and 23 slave monitors will be used, and by whom.

e. There is no justification for "rugged" site equipment.

f. Human factors are important, but there is no qualification of the characteristics "easy to use" and "call for needed data easily and quickly". A well thought-out command language with human engineered menu prompt pages could address this issue.

2.3 CONFIGURATION - The Sandia report does not discuss the use of specific peripherals, such as magnetic tapes, printers, displays, and slave units. The proposed configuration should be clarified to illustrate the functions being performed on each device; this will illustrate the use of each device as a system component and thereby help justify the overall system cost.

2.4 USER MANUAL. We recommend a more detailed specification for the contents of the users'manual. A basic outline of a users' manual would include:

a. initial operation (cold start, sign on, etc.)
b. procedures for loading and execution of NDL software
c. expected inputs and outputs
d. display formats (also, how to create or modify displays)
e. data formats and access procedures
f. operator control (kill jobs, erase/delete data, etc.)
g. file save/restore
h. error conditions and suggested recovery procedures
i. glossary of common terms
j. layout of equipment, component list
k. list of individuals to contact for problem situations

2.5 SOFTWARE SPECIFICATIONS - It is suggested that more serious attention be given to developing detailed software specifications, for both the central computer and the remote site computers, particularly in the following areas:

a. Data formats (for transmission, for storage, for display)

b. Operator command language (for specifying displays, selecting sensors/sites, submitting tables and control parameters, querying system performance, loading relevant software, performing data backup/restore operations, controlling the system after malfunction, etc.)

c. Display software (alphanumeric "pages", graphical plots, color maps, tabular printout, etc.)

d. Utility software (entry of conversion coefficients, sensor identification and labels, sensor channel assignments, etc.)

e. Network interface software (site-to-central, central-to-site, debug and test software)

f. Software design/development methodology (top down, structured approach, structured walk-throughs, etc.)

g. Software testing (simulation of sensors, simulation of errors, use of the Development Unit)

h. Software integration (structured build-up and sequential testing)

i. Configuration control (software problem reporting and tracking, debugging, documentation update, etc.)

j. Documentation generation and maintenance

A major advantage in creating these specifications soon is to stimulate thinking about what is expected from the NDL, and how NRC will use the system (i.e., operational scenarios).

2.6 MANAGEMENT INFORMATION SYSTEM. The development of a data base management information system does not appear justified at this time, based on the requirements as stated. The NDL concept is yet to be proven, and it is not clear as to how the data will be used, or whether the data will even be stored in a form to allow questions to be formulated and then answered.

We suggest that initially the data be collected and stored in a very simple, perhaps even inefficient format (see 2.10 below), and that during the Pilot-Phase the NRC develop FORTRAN programs to retrieve, process, and output data in formats To Be Determined. Then, as experience with data usage grows, the NRC will be in a better position to specify and procure the desired MIS software in time for the Operations-Phase.

2.7 FULL DUPLEX. There does not appear to be a clear requirement for full duplex transmission lines. Almost all data goes from the sites to the Operations Center; very little traffic flows in the other direction, and probably not simultaneously.

2.8 TIMELINES. In order to better size the required computer performance in terms of expected processing load, we recommend the use of a "timeline analysis" approach. That is, the computer resources needed for each processing function can be plotted as a function of time (e.g., .07 million operations per second from 10:00 to 11:00 A.M. daily for file save operations); the summation of all concurrent activities then characterizes the various resources required: processing power, number and types of peripherals, number and size of disk storage, core memory size, etc.

2.9 ACCURACY - It would appear that the accuracy requirements of 0.1 F and 0.1 % can be accomplished on the NDL with 13 bits (16 bits would most likely be used). This accuracy is difficult to achieve and maintain in remote locations. Calibration signals can be added by the site multiplexor to calibrate out A/D drift adding to the expense of the site data multiplexor.

2.10 DATA FORMAT REQUIREMENTS - It is recommended that the data be stored in the simplest possible format until the NDL has attained some maturity and NRC staff have gained experience in information extraction. Not only is the software effort non-trivial, but the effort may be wasted if the NDL concept is unsuccessful.

The following illustrates one possible record and file scheme.

"FILE" = consists of one complete day's worth of data, from all sites;

```
    /YY:DD:HH/, /RECORD 1/, /RECORD 2/, . . . /RECORD NNN/
---------------------------------------------------------------------
"RECORD" = consists of all site data received for a particular
minute;
    /MM/, /SET 1/, /SET 2/,  .... /SET 100/
---------------------------------------------------------------------
"SET" = data set scan of all data from one site
    /SITE ID/ MM:SS / N /D1/D2/D3/...../Dn/
---------------------------------------------------------------------
```

Each data element Di could be a 16-bit integer computer word (since input data is 12 bits); or, Di could be 32-bit floating point engineering value. The advantage of the integer form is that data storage is less, although conversion tables must also be stored (which is not needed for floating point data).

3.0 SYSTEM CONCEPTS

3.1 CENTRAL SYSTEM RECOMMENDED. The "Standard Data Acquisition System" is recommended over the "Stand-Alone System" because of economies of scale and because the primary responsibility for implementation and maintainence remains with the NRC instead of the licensees. The advantages of the Standard System are:

a. common identical software simplifies testing, maintenance and software staffing costs
b. interchangeable hardware facilitates repair, replacement (with spares), modification, and testing
c. utilizes same experienced staff for both hardware and software maintenance
d. avoids duplication of non-trivial costs for systems designs and developments (including new software each time)

3.2 TWO PHASE IMPLEMENTATION. We recommend that the NDL be implemented in two phases -- an initial "Pilot Phase" to demonstrate and validate the NDL concept, followed by the full "Operations Phase". The Pilot Phase allows for demonstration of concept, learning period, and experience with licensee implementation and operation. During the Pilot Phase the NRC may discover, for example, that alternative implementation concepts may be preferred. This two-phase approach would also spread out the relatively large capital costs of the system.

3.3 SINGLE SOFTWARE DEVELOPER - We recommend that one programming group be responsible for the design, development, implementation, maintenance, and documentation for all software - both for the Operations Center computers as well as the remote Site Terminals. The advantages are:

a. single management focus for control
b. encourages efficient software development; facilitates software testing - especially the software involved in transmitting/receiving data
c. simplifies software maintenance; single experienced maintenance group
d. shared software experiences on network system
e. common awareness of systems approach

The NRC may elect to have a second "independent" software group perform testing and validation of software developed by the primary group.

This recommendation is independent of the central vs. distributed recommendation, and does not imply that identical computers must be installed throughout the NDL network.

3.4 INTERFACE CONTROL DOCUMENT. The "thin interface" between the NDL and the licensee should be defined in considerable detail. Specifics should include number of sensed parameters (e.g., 140 at every site?), power requirements, electrical connections, data accuracy, Universal Time Code, data sampling rates, etc. Hopefully, the interface requirements are not unique to each site.

3.5 VAX - There is some question as to whether a VAX is overkill for this operation. Based on our experience, an 11/44 might also be able to do this job, and at the same time be more compatible with the PDP-11/xx front end and site computers.

The VAX and PDP computers are very well suited to numerical analysis, data display, and data management functions; also, software development is facilitated by excellent user support services. However, the NRC may consider other computer systems, such as Hewlett-Packard and SEL, which are also well suited to this application, particulary with respect to data acquisition, real-time data processing, and data display.

On the other hand, the VAX is an excellent computer resource investment for NRC, since it would provide NRC with a powerful and flexible tool for future data processing needs.

3.6 MANAGEMENT INFORMATION SYSTEM - There is no vendor-supported data base management information system for the VAX. Sandia will have to procure DRS or some other VAX-compatible system, or write one themselves; this can be very expensive.

Since the NDL is a new concept, there is some question regarding the utility and function of the data that will be generated. When there is no experience with data in this context, it may be premature to install a MIS. We recommend that any procurement of an MIS be postponed until there is more experience with the operation and resultant data output; this experience will occur during the Pilot Phase.

3.7 STANDARDIZATION - We recommend that, given the Standard Data Acquisition System, the site terminal unit should be a standard, replicable item, so that every site has exactly the same unit.

This considerably reduces costs for hardware maintenance (spare parts, same documentation, experienced engineers, etc.) and software maintenance (new fixes, testing on other units, same documentation, experienced programmers, easy to train new personnel, etc.)

In addition, this approach would encourage stockpiling of spare units and parts, which in turn would permit rapid replacement of failed parts and provide more freedom to get those parts repaired.

NDL development should be coordinated with the other new developments (e.g., TSC) being planned by the NRC. There may be savings in using similar system designs, implementation approaches, and software.

As part of this approach, we recommend that a separate site terminal system be installed at the Operations Center. This "development unit" would be used for software development, testing, and maintenance; it would therefore have additional peripherals (e.g., printers, magnetic tapes) to support these functions. (See 3.11 below).

3.8 SYSTEMS APPROACH. The proposal addresses the technical and cost issues of implementing the NDL data system, but does not consider several peripheral issues such as:

a. cost to install and maintain Site Terminals
b. cost to licensees in terms of staffing, skills, etc.
c. guidelines to licensees on installation/checkout
d. long term maintenance (including equipment overhaul and replacement with newer technology, especially since some of the proposed equipment has a three-year design lifetime)
e. provision for routine preventative maintenance and software maintenance as well as emergency remedial maintenance

It may be, for example, that the licensee costs to implement this system may well exceed the initial outlay.

3.9 COMPATIBLE COMPUTERS. Considerable advantages result from using computers that can run the same software (applications programs). For example, a PDP-11/34 could be used at the sites and a PDP-11/44 in the Operations Center.

We recommend consideration of the PDP-11/23 as a desirable alternative to the LSI-11 microcomputer. The PFP-11/23 costs several 8K more, but is not as restrictive in performance and software capabilities as the LSI-11.

3.10 4800 BAUD. The 4800 baud rate is more than sufficient to handle traffic from all sites to the Operations Center. In fact, it may be more bandwidth than required, given other system implementations.

However, the limitations of this medium need to be known. The noise is usually pulse or click noise rather than Gaussian. The most severe outages are due to thunderstorms, so that installing redundant lines would not add significantly to the reliability of the link.

Since all the data will be transmitted every minute, error correction codes are not recommended. However, error detecting codes could be included to flag questionable data (for which the Operations Center could request retransmission). The error detection code will only detect errors due to telephone line noise and disturbances. Error detection is easier to accomplish than error correction.

Another possibility is to simply send the same data twice, and let the Operations Center react to differences in the data.

3.11 DEVELOPMENT UNIT - One additional Site Terminal should be procured and installed in the Operations Center, for purposes of software development/testing, communications testing, and sensor validation (to the extent possible). Since there is always room for improvements to Site Terminal software, the modified software can be developed and tested thoroughly on this development unit, then disseminated to all field units on a covenient easy-to-install medium (cassette or telephone link).

With some additional capability to dynamically simulate sensor data, this unit can very effectively be used for training Operations Center operators and software personnel.

4.0 OTHER DESIGN CONSIDERATIONS

4.1 LIMIT CHECKING - The displays selected by the operator contain only a small fraction of all data. The operator may miss problems occurring in sensors at sites not being displayed, or even miss one of the many numbers being displayed and updated continuously on the screen. Therefore, consideration should be given to automatic limit checking for ALL sensors from ALL sites in real-time (This is normally done in satellite system testing on our PDP-11/34 class computers). That is, the Operations Center computer can, each minute, scan all data being collected from each site, and compare each value against pre-specified high and low limits; when the real value exceeds the limits range, an audible alarm and/or printout will notify the NRC operator.

A typical printed message could state, for example:

SITE ii, SENSOR jj HAS VALUE nn.nn **** LIMITS ARE (11.1,hhh.h)

This limit checking capability permits monitoring all sensors independent of which sensors/sites are currently being displayed.

Limit values would have to be maintained by NRC staff (e.g., the software development team) and entered as site-specific data.

4.2 TREND ANALYSIS - While there is definite need to have the data 30 minutes preceding an event, some consideration should be given to saving ALL data daily on magnetic tape, so that pre-incident data can be studied to determine if any trends or correlation between sensors could have helped predict the incident. Since the NDL is a new concept, the data collected now should not be destroyed since it may ultimately be considered more valuable.

With data stored on magnetic tape (i.e., a "history file") in format identical to disk storage, software programs could be developed to extract additional information from either source. In addition, this tape could contain simulated sensor data to be used during software development and testing.

4.3 ASCII. The use of ASCII for NDL data is desirable for several reasons, but the asynchronous transmission of engineering unit values may require many characters (value, sign, decimal point, etc.). Instead, each 12-bit digital sample can be separated by software, hardware or firmware into three 4-bit pieces, and each 4-bit piece (0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F) can be transmitted as a pseudo-ASCII code (011xxxx). Thus only 3 characters per sample need be transmitted. This saves considerable communications bandwidth.

In addition, this approach saves considerable data storage since the data would be stored and manipulated in binary format; only 1% of the data (i.e., one site out of 100) needs to be processed for display.

Alternately, transmission of raw 12-bit binary data is also possible, using software error checking and retransmission routines.

4.4 SELF-TEST - Consideration should be given to developing mechanisms which would permit the NDL to test itself on a regular basis, say every hour. This could be accomplished by substituting a "control" record periodically for a "data" record during transmissions. Specific test information could include the sensor calibration, communications link test data, correctness of parameters displayed, etc.

As a possible design consideration, it would be desirable to call up the same display at NRC that appears on the TSC consoles.

In this environment where detection of malfunctions can result in dramatic consequences, it is very important to install a monitoring system which, while it cannot eliminate errors, certainly does not introduce new errors.

4.5 DATA FORMAT - It is suggested that the Site Terminal collect all 140 sensor 12-bit values and transmit a data set to the Operations Center in the form:

DATA RECORD

/TYPE/SITE ID/ MM:SS/ N / D1/D2/D3/............./D140/

where N = number of data (140), and the Di are the 12-bit data.
TYPE = type code for record

Corresponding to the above, a channel identification record may also need to be transmitted, say once per hour instead of a data record, and of the form:

CHANNEL RECORD

/TYPE/SITE ID/ HH:MM/ N / C1/C2/C3/................./C140/

where Ci are channel identification codes used by software to select calibrations, engineering units, and labels for displays. This also allows for formats to be altered under computer control.

4.6 DESIGN GOAL. Consideration should be given to designing the NDL to accommodate two incidents simultaneously, rather than just one. One incident alone may last several weeks or months, with continuous monitoring; the probability that another incident could occur during that time frame is not zero.

4.7 CATALOG. When a sensor parameter exhibits a problem, it would be desirable for the NRC operator to request, via the CRT terminal, a catalog of relevent information sources: detailed engineering drawings, documents, manuals describing plant design, etc. The computerized catalog could simply indicate where the desired information can be found.

4.8 SITE TERMINAL INDEPENDENCE. We suggest that some consideration be given to designing a site terminal unit with its own sensors and multiplexing system, independent of parallel sensors used by the licensee. Then the same unit can be replicated as needed, and no new software needs to be developed. Also, when changes are needed, the change can be developed and tested on one unit, then distributed to all site units for installation.

It is also recommended that a site terminal unit be placed in the Operations Center, for hands-on software development, testing (using simulated sensor data), and maintenance. This allows the central software team to make and distribute changes easily, and also permits off-line testing of sensor anomalies.

4.9 SITE DATA STORAGE - As an option, an inexpensive tape recorder (e.g., cassette) could be part of the Site Terminal and used to store data for about 30 minutes, in case of telephone line failure or central computer failure. Afterwards, the central computer can "load" data from this device.

4.10 RELIABILITY - In NREG-0696, the specifications typically call for unavailability goals of .001. No models for the calculations, no reliability models, nor any confidence level is noted. Unless something is understood by Sandia and not noted in their Proposal, the specification is quite open and subject to interpretation.

Given that redundancy in the Operations Center is not required, and that redundancy in telephone lines has no advantage during natural disasters, the most significant measures for overall systems reliability would appear to be the MTTF of the data acquisition system and the MTTR for the central computer system.

4.11 MULTIPLEXOR - "A standard multiplexor can be developed for NDL-unique sensors. Where sensors are near each other in a non-hostile environment, initial multiplexing and A/D conversion can be accomplished remotely, thereby reducig the number of wires (noise pickup) and crosstalk. Many remote sensors compromise accuracy when polled by independent non-identical electrical sources.

5.0 COST CONSIDERATIONS

The following estimates were made based on our experience with spacecraft data collection and monitoring systems which have similar requirements (albeit higher data rates) and similar computer systems.

As currently documented, NDL requirements and system speecifications are incomplete. In addition, individual system specifications are not directly traceable to requirements in the requirements document. As a result, the proposed "solution" and the sizing of the proposed systems are not fully traceable to the system specifications. This looseness in systems requirements, system specifications, and traceability of proposed designs will be reflected later in implementation schedule slips, cost overruns, and possibly systems performance.

5.1 COST DISTRIBUTION - The distribution of costs within the $20 million can be distributed in different ways. Based on our experience, the costs for the computer hardware is correct, but the costs for Site Terminal software (estimated at 3-5 man years) may be doubled, and the costs for operations Center software (estimated at 20-25 man years) may be almost halved. Our rationale is that even though microcomputers are small and inexpensive, microcomputer software development requires more sophistication than with bigger computers; and super-minis like the VAX are user-oriented to facilitate software development. Also, much of the cost for software is for systems integration and debugging, rather than for the more straight-forward design and programming tasks.

The costing should include the cost to licensees, the cost to install and maintain NDL site terminals, and the costs of space, power, environmental and safety control, special cabinets and furniture, and housekeeping.

5.2 DIRECT COST MATRIX - The following cost estimates for the centralized Standard Data Acquisition System, for the first three years, are based on similar scale spacecraft monitoring systems.

ITEM	SITE TERMINAL & COMMUNICATIONS	OPERATIONS CENTER
Hardware	$25K per STU x 80 units = $2000K (PDP11/23,interfaces)	$300K VAX computer 500K terminals, etc. 300K Modems, power etc 100K Development STU
Software Development	$800K (4my*2yr*$60K) (2my*2yr*$80K)	$1500K (8my*2yr*$60K) (4my*2yr*$80K)
Hardware Maintenance	2984K (8my*$60K)*3yr (200K parts)*3yr ($300K vendor)*3yr	750K ($200K vendor)*3yr ($50K parts)*3yr
Software Maintenance	780K (3my*$60K)*3yr (1my*$80K)*3yr	960K (4my*$60K)*3my (1my*$80K)*3yr
Operations	0	1500K (2my*3shift*$60K)*3yr (1 mgr *$80k) (1 technician *$60K)
	6.52 Million	5.91 Million

DIRECT COST = $12.4 million

When management and overhead costs are added to the above direct costs of $11.4 million, it is not unreasonable to expect a total cost to the government of between $15 to $20 million.

6.2 TWO PHASE DEVELOPMENT COSTS - The following estimate for the recommended two-phase implementation reflects the same final configuration as above, but only in the third year. Subsequent maintenance and operations costs would be identical.

PILOT PHASE - Operations Center plus 5 sites

Hardware	$25 x 5 = 125	1200
Software	$800	1500
Hardware Maintenance	280 (3my*$60) (50K parts) (50K vendor)	960
Software Maintenance	0	0
Operations	0	0

OPERATIONS PHASE - Remainder of sites

Hardware	$25 x 75 = 1875	0
Software	0	0
Hardware Maintenance	$980 (8my*$60k) (200K parts) (300K vendor)	750K
Operations	0	500K

DIRECT COST = $9.47 million.

ENCLOSURE 4

COMPARISON OF MANAGEMENT PLAN ALTERNATIVES

Division of Responsibility

A detailed allocation of responsibilities among system managers and implementors for each of the management plans is given in Table 1.

In all three plans the NRC would be responsible for:

- Overall program management
- Review of licensee data acquisition system
- Operations Center facility development
- Operations Center procedures and staff
- Lead plant agreements
- Telecommunications network contracting

In plans B and C Sandia or the Technical Integrator would be responsible for the items listed below. (Under plan A the NRC would be responsible for these items).

- Operations of the Sandia or Technical Integrator program office
- Program planning
- Planning and maintenance of costs and schedules
- Functional requirements and system definition
- NRC/licensee interface definition
- Operational tests and evaluations
- System performance assurance
- Management of contract(s)

Table 1

Responsibility	Plan A NRC/Contractor	Plan B NRC/Sandia	Plan C NRC/Technical Integrato
Overall program management	NRC	NRC	NRC
Review of licensec data acquisition system	NRC	NRC	NRC
Operations Center facility development	NRC	NRC	NRC
Operations Center procedures and staff	NRC	NRC	NRC
Lead plant agreements	NRC	NRC	NRC
Telecommunications network contracting	NRC	NRC	NRC
Operations of Sandia or Technical Integrator Program Office	NRC	Sandia (S)	Technical Integrator (T
Program planning	NRC	S	TI
Planning and maintenance of costs and schedules	NRC	S	TI
Functional requirements and systems definition	NRC	S	TI
NRC/licensee interface definition	NRC	S	TI
Operational tests and evaluations	NRC	S	TI
System performance assurance	NRC	S	TI
Procurement of contractor services	NRC	S	NRC/TI
Management of contract(s)	NRC	S	TI
System design and implementation	Contractor (C)	S	Contractor (C)
Detailed project plans	C	S	C
Telecommunications network definition	C	S	C
Operations center architecture and human factors	C	S	C
Hardware and standard software	C	Contractor (C)	C
Software development	C	C	C
Subcontracting as required	C	C	C
Post-installation services	C	C	C

The difference between plans B and C is that in plan C the NRC would contract out the following items with assistance from the Technical Integrator (that in plan B Sandia would itself perform or subcontract)

- System design and implementation
- Detailed project plans
- Telecommunications network definition
- Operations Center architecture and human factors
- Hardware and standard software
- Software development

In all three plans the NRC would not itself perform the items listed below:

- System design and implementation
- Hardware and standard software
- Software development
- Telecommunications network definition
- Operations Center architecture and human factors considerations
- Subcontracting as required

NRC Staff Needs

The NRC staff needs for each plan are given in Table 2.

Table 2

	Plan A (NRC Program Office)	Plan B (NRC/Sandia)	Plan C (NRC/Technical Integrator)
NRC Program Manager	1	1	1
Professional Staff	5	2	2
Administrative (including procurement support)	2	1	1

In addition, for plans A and C, substantial assistance from procurement and legal personnel, estimated at 1 person year, would be required during the NDL procurement phases.

Advantages and Disadvantages of Plans

All of the options for NRC implementation of the NDL must provide the NRC with the necessary managerial, technical and administrative talent necessary to design, procure and install a reliable computer based data transmission, processing, display and storage system while ensuring minimum life cycle system costs. Each of the options provides these capabilities in different ways. The relative advantages and disadvantages of each option are addressed below:

Plan A - NRC Program Office/Contractor Implementation Advantages:

- Relatively simple plan
- Can provide a contractor who would have broad experience in designing, installing and operating computer systems
- Provides option for obtaining maintenance from an organization familiar with total NDL system
- Minimizes the number of interfaces and clearly places responsibility
- Utilization of private enterprise and the competitive bidding system
- Allow range of implementation alternatives thereby encouraging innovation which could lower costs

Disadvantages

- NRC would have to staff and operate a program office comprising a program manager, five technical professionals and two administrative and procurement specialists
- Will take about 12 months for NRC to select the contractor

Plan B - NRC Program Manager/Sandia Implementation Advantages:

- Would relieve NRC of the substantial contracting burden associated with Plan A
- Would allow immediate start of detailed design and procurement efforts with possible savings in hardware and software costs which are subject to annual inflation increases

- NDL program can proceed without delay

- Fewer NRC personnel necessary than in concept A

- Costs associated with contractor familiarization and learning are reduced with consequent possible savings of time

Disadvantages:

- Less beneficial utilization of the competitive bidding process since the Sandia design concept would not be subject to refinement by opening up the detailed design to competitive bidding

- Elements of program control implicit in other plans lacking since Sandia would act as Technical Integrator and contractor and NRC would not operate a Program Office with as much technical depth

Plan C - NRC Program Manager/Technical Integrator/ System Contractors(s)

Advantages:

- Takes more advantage of the competitive bidding process than plan B by encouraging competitive system concepts

- Majority of NDL funds placed by competitive bid

- Management of project could be stronger than by NRC management if knowledgeable Technical Integrator chosen

- Allows NRC to engage services of an organization experienced in data communications systems to execute program office functions

- Provides expert help in evaluation tasks associated with NRC contracting and monitoring of contractor activities

Disadvantages:

- System integrator role will necessarily require some duplication of NRC tasks and additional interfaces over plan A.

Quality of End Product - None of the three arrangements has a clear advantage over the others. The technology needed is well within the state of the art.

Cost - Plan C could cost more than A or B but the enhanced control may actually result in lower total system cost.

It is doubtful that any reputable contractor will bid all portions of the program on a fixed-fee basis. Firm quotes on hardware and standard software should be obtainable but this represents only about one quarter of the estimated system implementation cost. A cost-plus-fee arrangement will probably be required for the bulk of the work. Therefore, even the competitive bidding in plans A and C do not ensure minimum cost.

Accountability - All three plans clearly fix accountability. In plan B it is with Sandia; in plan A it is with the contractor; in plan C it is with the Technical Integrator.

Schedule - Plan B appears superior. Sandia has spent the past year deeply involved not only in the concept study but also assisting the NRC in addressing a multitude of related problems. Additionally, utilization of Sandia through plan B could result in earlier installation of equipment at lead plants, thereby minimizing the risk of technical difficulties occurring late in the implementation program.

Plan A could have a severe impact on the schedule because of potential delays in staffing an NRC Program Office. Under plan C, delays of up to a year could occur in bringing a Technical Integrator on board if other than a not-for-profit entity is chosen. Choice of a Technical Integrator by competitive procurement from industry appears to have additional schedule disadvantages.

It should be noted, however, that systems at the nuclear facilities will not be ready to transmit data in most cases for 18 months so that "front end" NRC delays may not be significant.

NRC Staffing Requirements - Plan A would require staffing a special purpose, limited duration procurement activity for NDL implementation. This group would no longer be needed once the task is complete. Plans B or C require less NRC involvement in terms of staff.

Operational Arrangements - The NRC will wish to contract for certain operations, maintenance and training support after the NDL system has achieved full operational status. Plan A provides the opportunity to continue the contractor in this role. Under Plan C, one of the contractors under the Technical Integrator likely would be selected to fill this need. Sandia has indicated that they could not fulfill this role on a long-term basis; therefore, under plan B, an arrangement would have to be developed with a Sandia subcontractor or a new organization would have to be brought on board.

Monitoring and Control - It is important that the NRC either directly or through its agent be able to monitor the detailed work throughout the development period. Plan C may be the superior arrangement in this regard. An experienced Technical Integrator would be able to exercise full cognizance over all implementation activities and manage turnkey turnover to NRC as systems user supported by an appropriate systems maintenance contractor.

ENCLOSURE 5

A REQUEST FOR PROPOSAL
FOR THE JOB OF
SYSTEM INTEGRATOR
FOR IMPLEMENTATION OF THE
NUCLEAR DATA LINK

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Appendix 1 - Draft NDL Functional Characteristics and Operational Requirements

1.0 Nuclear Data Link Overview

1.1 Nuclear Data Link Function

The purpose of the Nuclear Data Link (NDL) is to reliably provide accurate, timely, and well-defined nuclear power plant data to assist the Nuclear Regulatory Commission (NRC) in performing its duties during an incident. The NDL allows the NRC to monitor, at the NRC Operations Center in Bethesda, MD., reactor systems, balance of plant systems, radiological, and meteorological data from all licensed and operating nuclear power plants. The NRC, by virtue of its position as nuclear industry regulator, is involved in any incident that has the potential for affecting the public health and safety. In this position, decisions are made and functions carried out that require an independent NRC evaluation of the plant conditions and the real or potential effect on the public and environment. The data provided by the NDL permits the NRC to perform these functions. It allows the NRC to be assured that the Licensee is taking appropriate action to mitigate the effects of an incident, to independently evaluate the plant's situation, to provide information and advice to other federal and state agencies, and, if required, to provide assistance and consultation to the Licensee.

1.2 Life of the Nuclear Data Link

The NDL must be a viable system until the end of the Nuclear Fission Power Reactor Industry life. For planning purpose with respect to design of the NDL, 2040AD will be used as the end of industry life.

1.3 Conceptual Illustration

To provide a common framework for discussion, a conceptual illustration of the NDL is presented in Figure 1. The terms shown thereon will be used hereinafter without further definition. It is emphasized that Figure 1 is only a conceptual illustration and is not intended to indicate any particular design. The draft functional requirements for the NDL are given in Appendix 1.

2.0 Nuclear Data Link Program Management

2.1 Role of the Nuclear Regulatory Commission

The NRC provides the overall program management, defines the basic system characteristics and requirements, establishes the total project and annual funding levels, coordinates the

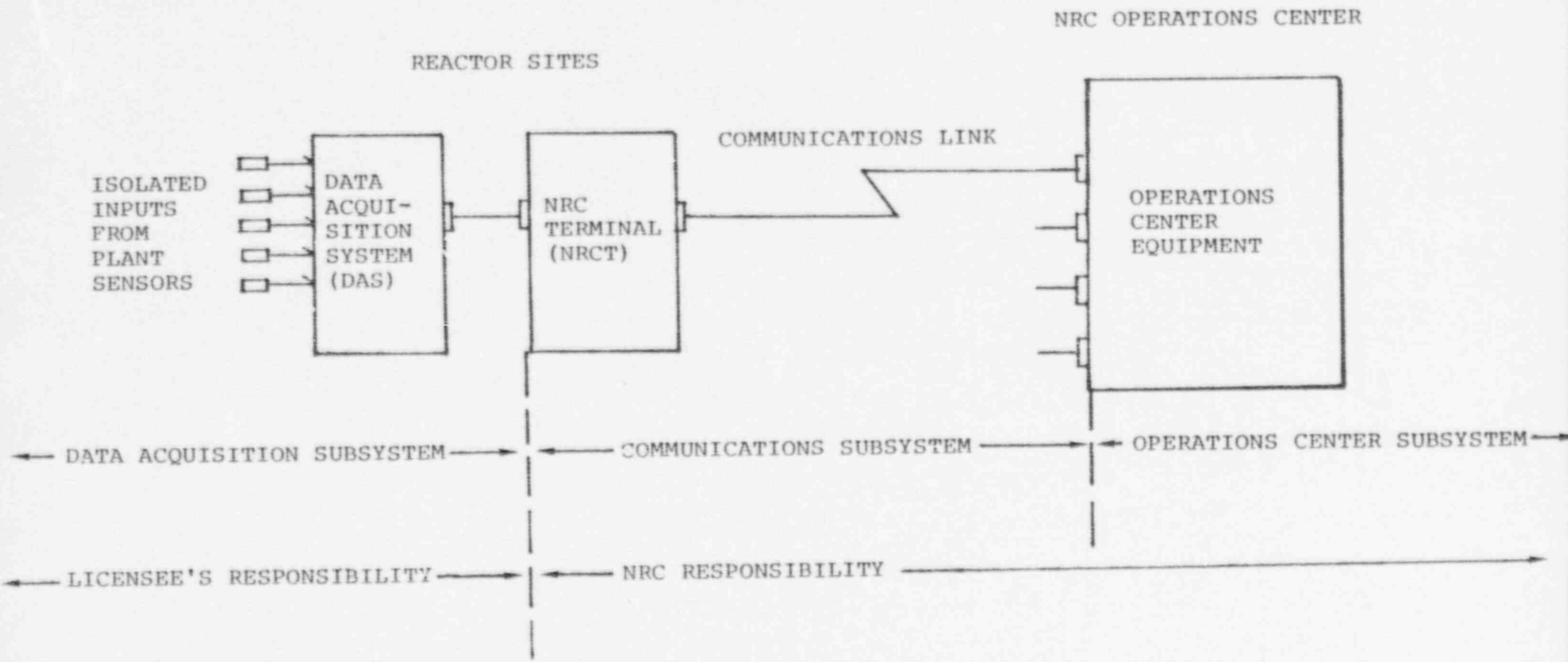

FIGURE 1. NDL CONCEPTUAL ILLUSTRATION

general program requirements with other federal agencies and the Licensees, and reviews and approves all plans and deliverable documents. The NRC is responsible for establishing agreements with Licensees willing to participate in NDL development in early prototype installations (lead plants). Similarly, the NRC issues to all Licensees specific requirements for the plant data acquisition subsystem (DAS) which defines the DAS functional requirements and the standard interface between the DAS and the NRC Terminal (NRCT). The building and physical plant facilities for the Operations Center are to be provided by the NRC based upon both NDL requirements provided by the NDL contractor, and other requirements arising from the other Operations Center functions. These other Operations Center functions include (1) operation of voice communications network to all reactor sites which includes a voice communications console, (2) the use of the National Institute of Health computer for data base management of non-telemetered, manually reported data, (3) operation of a computer-controlled map display system, (4) radiological consequence modeling and associated meteorological trajectory and dispersion analysis, and (5) a microfilm storage and retrieval system. References 3.2.11, 3.2.12, and 3.2.13 provide background information on the functions of Operations Center. The NRC is responsible for integrating all Operations Center functions into a composite, workable facility. Close liaison between the NDL System Integrator and the NRC will be required to accomplish this program. The NRC is the ultimate user of the NDL and as such provides the necessary staff or means to operate and maintain the system.

2.2 Role of the System Integrator

The System Integrator functions as the program office which provides technical and administrative control of the NDL project. He conducts program planning, coordination, and liaison activities and keeps the NRC apprised of project progress and problems. The System Integrator defines the overall NDL system by translating system characteristics and operational requirements into functional requirements and specifications. He handles all program contracting including RFQ preparation, proposal evaluation, contract negotiation and award, and contract administration. The System Integrator controls the distribution of all contractual funds and is responsible for the evaluation and acceptance of all contractor deliverables. The System Integrator is also responsible for end to end testing of the NDL system.

2.3 Role of NDL Contractors

The actual design and implementation of the NRC portion of the system is to be executed by private industrial concerns via competitive bid, contractual arrangements established by the System Integrator. Such contracts must be written, monitored and enforced by the System Integrator in a manner which will ensure timely and cost effective delivery of a high quality product. The System Integrator must select the work package and contractual arrangements best suited to achieve these objectives.

3.0 References

3.1 General

The following list of references provides a detailed view of NDL project background, work to date, and the organizational framework affecting the project. It is incumbent upon respondents to obtain these documents. Unless otherwise noted, documents may be obtained from the following source:

U. S. Nuclear Regulatory Commission
Attn: Sales Manager (or Publications
Unit as noted)
Washington, DC 20555

In the event of inconsistencies between any documents and this RFP, the requirements of this RFP shall prevail.

3.2 Reference List

3.2.1 U. S. Nuclear Regulatory Commission, "Functional Criteria for Emergency Response Facilities," USNRC Report NUREG-0696, July 1980. (Publications Unit)

3.2.2 U. S. Nuclear Regulatory Commission, "Report to Congress: NRC Incident Response Plan," USNRC Report NUREG-0728, Sept. 1980. (Sales, $3.00)

3.2.3 U. S. Nuclear Regulatory Commission, "Report to Congress on the Acquisition of Reactor Data for the NRC Operations Center," USNRC Report NUREG-0730, Sept. 1980. (Sales, $2.00)

3.2.4 U. S. Nuclear Regulatory Commission and Federal Emergency Management Agency, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," USNRC Report NUREG-0654, FEMA Report FEMA-REP-1, January 1980. (Sales, $5.50)

3.2.5 NRC Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident," Revision 2, May 1980. (Final Issue not yet published.)

3.2.6 NRC Regulatory Guide 1.23, "Meteorological Programs in Support of Nuclear Power Plants," Proposed Revision 1, September 1980. (Final issue not yet published.)

3.2.7 U. S. Nuclear Regulatory Commission, "Conceptual and Programmatic Framework for the Proposed Nuclear Data Link," Sandia National Laboratories, NRC Report NUREG/CR-1451, June 1980. (Sales $5.00)

3.2.8 U. S. Nuclear Regulatory Commission, "Considerations on Nuclear Data Link Implementation in Relation to the Technical Support Center, Emergency Operations Facility, and the Safety Parameter Display System," Sandia National Laboratories, USNRC Report NUREG/CR-1579, July 1980. (Sales $2.00)

3.2.9 Research Triangle Institute, "Review of Nuclear Data Link Conceptual and Programmatic Framework," Aug. 1980.

3.2.10 Tony Villasenor, NASA letter to NRC, no date, subject: Review of Proposed Nuclear Data Link (Attached to RFP).

3.2.11 T. Gasparotti, J. Himes, E. Janicik, D. Wolfe, "Communications and Control to Support Incident Management: Initial Operations Center Design Considerations," Mitre Corporation Working Paper: MTR-WP-79W00797, Dec. 1979, Not formally published (attached to RFP).

3.2.12 J. Himes, J. Hannan, D. Wolf, "Conceptual Design of the NRC Headquarters Operations Center, User Needs for Nuclear Data Link Information," The Mitre Corp., USNRC Report NUREG/CR-1740, Oct. 1980 (originally published as MTR-80W00059, May 1980). (Sales)

3.2.13 J. Hannan, J. Himes, "Conceptual Design of the NRC Headquarters Operations Center, User Needs for Radiological and Meteorological Data," The Mitre Corp., USNRC Report NUREG/CR-1739, Oct. 1980 (originally published as MTR-80W00183, June 1980). (Sales

3.2.14 T. Unkelhaeuser, R. Jones, "Design Critieria for Nuclear Data Link Communications Subsystem," Sandia National Laboratories, SAND80-0738, USNRC Report NUREG/CR-1839, Dec. 1980.

3.2.15 Licensee Data Acquisition System/NRC Terminal Interface Specification. (Attached to RFP)

3.2.16 MIL-S-52779A, "Software Quality Assurance Program Requirements," 1 August 1979 (Available from Global Engineering Documentation Service, 3950 Campus Drive, Newport Beach, CA 92660. Phone 1-800-854-7179).

3.2.17 Department of Defense, "Automated Data Systems Documentation Standards," Standard 7935.1-S, 13 Sept. 1977. (Available from NTIS) Springfield, Va. 22161

3.2.18 U. S. Nuclear Regulatory Commission, "Report to Congress on NRC Emergency Communications," USNRC Report NUREG-0729, Sept. 1980 (Sales $3.75)

4.0 Scope and Duration of the Program

4.1 Scope

This RFP is for the system integration task for the NRC portion of the NDL system as defined by Figure 1. Paragraph 6.0 defines the tasks to be accomplished under this contract. The contract will be awarded for the entire project (four years), however, obligation of funds will be on a government fiscal year basis.

4.2 Schedule

The overall goal of the project is to have all licensed power reactors connected to the NDL system four years from the award of this contract. The Operations Center and lead plant installations should be completed three years from contract award.

5.0 Proposal Preparation and Evaluation

5.1 Proposal Preparation

5.1.1 General

Responses must encompass all tasks and the respondent must be prepared to perform all work specified in each task.

5.1.2 Technical Proposal

5.1.2.1 Program Management Plan. The proposal must clearly indicate in a Program Management Plan the respondent's intended program management and control approach.

5.1.2.2 Program Schedule. Proposals must present a tentative schedule for the entire program showing how each task will be phased and how the overall program will be meshed together.

5.1.2.3 Contracting. The proposal must indicate the respondent's plans for contracting for NDL implementation. The breakdown of major acquisitions should be specified along with the general approach for acquiring these goods and services.

5.1.2.4 Staffing. The proposal must clearly indicate the proposed System Integrator staffing and program management team organization.

5.1.2.5 Quality Assurance. The proposal must indicate the general approach toward program quality assurance.

5.1.2.6 Resources. Furnish information on organizational structure, facilities, material resources and professional staff that will be utilized in the execution of the work.

5.1.2.7 Experience. Furnish information on similar work performed for others.

5.1.3 Cost Quotation

In accordance with the Statement of Work, the respondent is to provide the resources which include personnel facilities, equipment, and material to perform all tasks given in Paragraph 6.0. Proposals must provide an itemized estimate by government fiscal year with manpower, travel, computer and equipment costs specifically identified. Fees over and above estimated full cost recovery should be clearly stated.

5.2 Proposal Submission

5.2.1 Due Date. Proposals must be received by the USNRC Office of Administration not later than 3:00 EST, 60 days from the issuance of this RFP.

5.2.2 Number of Copies. Ten (10) copies of the proposal must be submitted.

5.2.3 Format. Proposals must be prepared in an 8-1/2" x 11" format and typed with not more than 12 characters per inch.

5.3 Proposal Evaluation

5.3.1 Technical Proposal Evaluation. Each proposal will be evaluated by an NRC team using the criteria listed below.

5.3.1.1 Program Management. How complete and well structured is the Program Management Plan, the proposed program schedule, the proposed contracting arrangements, and the proposed approach to quality assurance? (Weight 50)

5.3.1.2 Resources. To what degree is the proposed staffing level consistent with the program schedule? To what degree is the proposed staffing consistent with program needs with respect to education and experience? (Weight 25)

5.3.1.3 Understanding of Objectives. To what degree are the responses to the items in Paragraph 5.1 relevant to the NDL implementation plan? Does the response demonstrate understanding of the overall NRC objectives for the NDL? Cost quotations will be considered in determining the respondent's understanding of the Statement of Work and his ability to organize and manage the program. (Weight 25)

6.0 Statement of Work and Task Description

6.1 Statement of Work

The respondent shall provide all the necessary resources including personnel, facilities, equipment and materials to execute the task of Nuclear Data Link System Integrator described below.

6.2 System Integrator Task Description

6.2.1 Program Office. The System Integrator will establish and maintain a Program Office to provide technical and administrative direction and control of the NDL implementation program. This office will be responsible for program planning, coordination, and liaison activities and for keeping the NRC apprised in a timely manner of program progress and problems.

6.2.2 Functional Requirements and System Definition. The System Integrator will establish the overall system definition by translating the system characteristics and requirements, provided by the NRC, into functional requirements and specifications.

6.2.3 NRC/Licensee Interface Requirements. The System Integrator will develop and provide the NRC with carefully documented interface requirements for the transmission of data from the licensee data acquisition system to the NRC Terminal. These requirements will include definition of space, power and physical interconnections for the NRC Terminal.

6.2.4 Contracting. The System Integrator will develop work package definition and specifications for the various components of the system. These packages will be formulated into a request for quotation and competitive bids will be solicited from an approved bidders' list of private industrial organizations. The System Integrator will evaluate, according to predetermined criteria, the various proposals and select a contractor(for implementation of the various system components. The System Integrator will negotiate, place, monitor and enforce all contracts. The System Integrator must reserve the right to directly procure third party goods and services associated with any contractor proposal.

6.2.5 Program Planning and Control. The System Integrator will define and maintain the overall program implementation plan. Detailed planning documents are to be developed by the contractor(s) according to standards specified by the System Integrator. These detailed plans, after review and approval by the System Integrator, serve as the basis for system implementation. The System Integrator will maintain close cognizance of contractor work progress and adherence to agreed upon financial plans. Contractor developed plans for hardware acceptance tests, computer hardware and software benchmark tests, and software verification and validation tests must be required. System Integrator approval of these plans and validation of the subject tests must be used in assessing work progress. The System Integrator will maintain the program financial plan and exercise fiscal control over all contracts. The System Integrator will conduct periodic program reviews with all contractors with NRC representatives present to ensure that all parties are fully apprised of program progress.

6.2.6 Operational Testing and Evaluation. The System Integrator will develop a complete operational test and evaluation plan. These tests must provide a complete verification of system performance. As such, they will provide the basis of NRC acceptance of the NDL system.

6.2.7 Operations Center Facility. The System Integrator will work closely with the NRC to develop an efficient layout of the NDL equipment within the Operations Center. The System Integrator must ensure that the NRC is fully aware of all special requirements for power, environmental conditioning, etc., that might impact the availability of this facility.