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FUNCTIONAL NEEDS UPDATE AND STATUS REPORT ON THE DHLWM ADVANCED COMPUTER REVIEW SYSTEM

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Prepared by

Rawley D. Johnson
Robert L. Marshall
Steven W. Dellenback

Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

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1. INTRODUCTION

Under the requirements of the Nuclear Waste Policy Act (NWPA) and its amendments, the U.S. Department of Energy (DOE) is required to submit to the U.S. Nuclear Regulatory Commission (NRC) a license application for the construction and operation of a mined geologic repository for the disposal of high-level radioactive waste (HLW). The repository is a large Federal program that will span several decades. The DOE has been collecting data and information about the proposed high-level waste repository site at Yucca Mountain since 1978. Already, over 12 years of site-specific data and information exist in addition to a large body of general related information that needs to be synthesized and understood by the NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA or the Center) staffs.

DOE has a large organization and a number of contractors working on this project. DOE and its contractors have been using computer programs (software) to process, manage, and then analyze data. They are and will be using predictive models (embodied in computer programs) to conduct safety analyses and they will be using computer programs to design the facilities. Given the existing computer technology and what will develop over the duration of this project, it can be assumed that DOE will make greater use of computers and computer software to do the analyses and designs, and to support the management of the project.

In response to the need to review such a large amount of technical data already accumulated with much more expected in the years ahead, it is imperative that the Division of High-Level Waste Management (DHLWM) implement appropriate computer capabilities and develop associated staff expertise. The NRC has decided to support development of staff expertise and capabilities, to utilize analytical codes and to implement a pilot program for advanced computer technology in the agency.

1.1. BACKGROUND

In fulfilling its regulatory responsibility under the NWPA, the NRC has promulgated requirements in 10 CFR Part 60 which will necessitate both probabilistic and deterministic analyses. Such analyses require a sophisticated technical review capability to determine compliance with these requirements. A memorandum from the Executive Director to the Commissioners on "Staff Expertise and Capabilities to Utilize Analytical Codes" (SECY-91-247) generally describes the basis of need for this sophisticated review capability, (NRC EDO22, 1991a).

The DHLWM must prepare for a very unique licensing situation with respect to the high-level waste repository. After more than 10 years of prelicense application interaction with the DOE, the NRC must review a repository application in 3 years, making all the necessary technical evaluations in 18 months or less, with 18 months allowed for the licensing hearings.

The DHLWM has determined and documented its functional needs for computer hardware and software to support its regulatory responsibilities and prelicensing consultation role with DOE in the "DHLWM Computer Hardware and Software Functional Needs and Some Proposed Specific Needs" report completed in August 1990, (Chery, 1990a). The planned system is called the DHLWM Advanced Computer Review System and it has been selected as one of the pilot programs for early

implementation of advanced computer technology in the agency. The Center informally participated in the development of that report by providing information on the Center's computer capabilities and interfaces in supporting the NRC DHLWM.

1.2. PURPOSE

The purpose of this task is for the Center to provide a functional needs update and status report (Subtask 1) and prepare a design and implementation schedule for computer hardware and software (Subtask 2) in the context of an integrated plan for the DHLWM, (Chery and Fortuna, 1992). The interface to organizations such as the Center, Office of Nuclear Regulatory Research (RES), DOE and others has been considered, of course, but this update is not intended to describe functional needs for such supporting organizations. The purpose of this draft report is to update the functional needs identified in the referenced 1990 report (Chery, 1990a) and further quantify and order the priorities for implementing appropriate computer capabilities to meet the DHLWM needs.

1.3. METHODOLOGY USED AND BASIC NEEDS IDENTIFIED

Since the Center began work on this task in March 1992, it has reviewed the 1990 report (Chery, 1990a) and gathered updated information, particularly on the status of existing and planned NRC systems. This was accomplished by conducting a survey based on a list of the NRC's HLW program activities projected for FY93-97 (NRC NMSS, 1992b). The activities were associated with blank columns on the survey form for requested information on required computer functions, applications, hardware, software, interfaces and related priorities. A series of eight meetings with over 25 staff members which included representatives of Offices of Information Resources Management (IRM), RES and DHLWM management, operations, and technical staff was held over a two-day period. Discussions with them confirmed that the scope of functional needs in their major program areas has not changed in any fundamental way.

A basic requirement identified for all personnel interviewed was improved office automation and network connectivity. The networking capability and high performance technical computing capability must meet the needs of DHLWM for a prelicensing technical review period of about 10 years, the licensing period, and then through the performance confirmation period. The initiatives to implement the Agency Upgrade of Technology for Office Systems (AUTOS) (Gianios, 1991) and the development of a High-Performance technical review computer system in the DHLWM (NRC EDO, 1991a) both contribute in a complementary way to meeting these needs. These plans for improving the efficiency and effectiveness of the DHLWM staff, by their very nature, introduce additional resource requirements for integrating system support and end-users applications that will be addressed in the design phase of this project.

1.4. ASSUMPTIONS

Certain assumptions were made by the NRC in their 1990 report (Chery, 1990a) on which to base the evaluation of computer capability needs and the eventual system design. Those assumptions are reiterated below.

- NRC technical staff will have "read-only access" to DOE databases and computer programs (codes), where they reside on DOE computers, through high-speed communication lines.

- The earliest the Licensing Support System (LSS) will be available for retrieval (by all users) of text (and image) information from documents and correspondence is early FY1998.*

- In addition to the NRC-supported Nuclear Document System (NUDOCS), the DHLWM will maintain and support access to intradivisional reference document data bases [e.g., Hydrologic Transport technical reference data base and the references of the Site Characterization Plan (SCP)]** until the LSS becomes operational.

- NRC technical staff will be expected to use available methods, models, and codes, and to develop methods, models, and computer programs.

- NRC technical staff will be trained and provided necessary and appropriate experience to become competent with model theories, data requirements, program operation, and analysis of results.

The following assumption was revised slightly from the 1990 report in a facsimile transmittal from D. Chery and S. Fortuna, dated April 3, 1992.

- NRC DHLWM technical staff will be provided with the computer hardware and software that is required to support DHLWM functional needs.

The following two assumptions were added at the request of D. Chery and S. Fortuna in a facsimile transmittal dated April 3, 1992.

- The Office of Information Resource Management (IRM) will provide the resources required to support the operation and maintenance of a network which supports workstations [such as Reduced Instruction Set Computer (RISC) based configurations with UNIX operating systems and Graphic User Interfaces (GUI), personal computers, and wide-area network communications].

- The number of NRC DHLWM technical staff that will be using the advanced computer capabilities for analytical work initially will be 20 individuals with expected expansion in five years to 30 individuals.

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* Assumption revised to be consistent with SECY-92-195, for The Commissioners, from L. S. Donnelly and J. M. Taylor, May 28, 1992.

** This assumption was changed by D. Chery to include the word "intradivisional."

2. PROGRAM REQUIREMENTS UPDATE

2.1. PROGRAM ACTIVITY DESCRIPTIONS

The overall scope and definition of the program activities have not changed, in general, since the August 1990 report (Chery, 1990a) was issued. Descriptions of the six program areas found in that report prepared by DHLWM are provided below.

2.1.1. License Review Capability

Resources are needed for the technical staff to develop methods and capabilities to independently evaluate DOE's License Application. The overall need to develop this capability has been covered, for the purpose of DHLWM's planning and budget assumptions, in the "Licensing Review Capability" program area, which has been divided into three major subordinate program areas.

2.1.1.1. (1) Analysis method preparation

A fundamental aspect of the license review capability will be the development and use of various technical analyses that will be needed to evaluate DOE's investigations, reports, demonstrations of favorable and adverse conditions, and evaluations of subsystem performance. Such analyses will be involved in many aspects of preparing for and making a license review, such as natural systems descriptions, representation of natural system processes, subsystem modeling, engineered barrier design, waste package design, and the operations facilities design.

2.1.1.2. (2) Iterative performance assessment

A significant aspect of the license review capability and the analysis method involved understanding and developing a methodology to conduct a performance assessment (PA) of the overall repository system, thereby determining whether the Environmental Protection Agency (EPA) standards have been met. Performance assessment is a synthesis that requires the foundation of and information from the "analysis methods" activities. Thus, in addition to the needs for the "analysis methods," performance assessment has some additional specific needs.

2.1.1.3. (3) Review plans preparation

The staff will prepare a number of review plans, to guide its review of DOE's overall licensing program. A License Application Review Plan (LARP) will guide the staff's review of the data collection activities, data, and assessments in the License Application (LA) review. The LARP will integrate and focus the staff's regulatory programs and analysis method capabilities with the review criteria and procedures which the staff will use to conduct its independent review of DOE's (U.S. Department of Energy, 1990) LA, including PA. In developing the LARP, the staff will develop a License Application Review Strategy (LARS).

2.1.2. Site Characterization Review

2.1.2.1. (4) Report review

NRC review of the SCP progress reports will focus on (i) new information about the site, design, and performance estimates; (ii) new issues and plans to resolve them; (iii) changes to the original plans and schedules; and (iv) DOE's progress toward resolving potential licensing issues. NRC also will be reviewing Study Plans, Site/Repository Technical Reports, and Major Design Reports. Technical staff will be involved in technical "interactions" with DOE technical staff, Advisory Committee on Nuclear Waste (ACNW), Nuclear Waste Technical Review Board (NWTRB), and National Academy of Science (NAS).

Since the basis for satisfying the information needs arising from the regulatory requirements regarding the protection of public health and safety will be, in part, the extensive amount of data collected from site characterization, this activity will provide the major amount of material that can be used in the development of the license review capability as described in Section 2.1.1.3. As information from site characterization becomes available, these data will be used by the NRC technical staff, to the extent they are able with the provided computer resources, to gain experience and independently examine, test, and validate DOE's demonstrations of various components of the geologic repository performance.

2.1.3. NWPA Regulatory Requirements and Guidance

2.1.3.1. (5) Rulemaking support, technical positions, systematic regulatory analysis, and LA format and content guide

To provide reasonable assurance that DOE's license application can be reviewed within the 3-year period mandated by the NWPA, NRC will provide, by FY98, appropriate and timely regulatory guidance to DOE. NRC will develop technical positions to clarify the meaning of certain requirements of 10 CFR Part 60, describe what must be proven to demonstrate compliance with the NRC regulations, give criteria for acceptable testing or analysis methods, and resolve potential licensing issues.

2.1.4. Management Support and Other Functions

2.1.4.1. (6) Management support

Certain management functions must be performed to support the technical analyses, review plan preparation, reviews, and management of the program. Management support for electronically communicating briefing charts, meeting materials, indexing, and retrieval of correspondence, spreadsheets and project schedules for operating plans, five-year plans, and cost reporting are primary activities.

2.2. ANALYSIS OF NEEDS

An analysis of the needs for computer functions to support the program activities described in Section 2.1 was performed. Five categories of computer applications have been identified as follows:

(1) High-Performance Technical Computing;
(2) Database Access/Document References;
(3) Systematic Regulatory Analysis;
(4) Project Management; and
(5) Office Automation.

In the following two subsections (2.2.1 and 2.2.2) and corresponding tables (2-1 and 2-2), the DHLWM computer support needs are described relative to each of these five categories. The design of the computer hardware, network system and specification of software will be based on the needs in each of these five categories.

2.2.1. Analysis of Program Activities

The six program activities described in Section 2.1 and their corresponding computer capabilities, identified in the 1990 report and confirmed in the Centers survey, have been grouped in the five application categories in Table 2-1. The last two columns in Table 2-1 associated with each computer function and specific capability needed for a program activity are the "organization, system, and database interfaces" and an "indication of need" for the computer support. Information from the 1990 report (Chery, 1990a) and resulting from the methodology used to prepare this update was used to identify the organization's systems and databases that DHLWM staff need to interface with in performing the program activities.

Since there are program and budget constraints on the design and implementation of the appropriate computer system, an indication of the need for computer support for each program activity and specific computer capability was determined. It was decided that what the staff "must have" versus what would make an "improvement" in performing the program activities would be used in this level of analysis as a means to rank the relative importance of the function. The definition of "must have" in the context of its use here is that it is felt the DHLWM staff must have an advanced automated capability to handle the volume and provide the necessary quality product in support of the designated program activity. The use of "improvement" designates that the automated or manual capability currently used to perform the function should be improved.

The information in Table 2-1 is being used as the basis in this report and the upcoming design for quantifying the number of users for the given functions, the approximate volumes of data storage and file transfers, the specific computing capabilities required within each application area and connectivity requirements to other personal computers, workstations, mainframes, and supercomputers in other organizations via LAN's and WAN's.

2.2.2. Analysis of Computer Functions

The proposed DHLWM advanced computer review system will consist of high-performance computer workstations integrated with the staff's personal computers and special peripheral equipment, and will include special software packages and appropriate access to the necessary external data bases, to support the technical review of DOE's license application. During the lifetime of the project, this system will be capable of accessing the complete DOE data collections, technical and performance evaluations, and engineering designs for the high-level waste repository. It will also use advanced scientific visualization methods, geosciences information

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
HIGH-PERFORMANCE COMPUTING			
Analysis Method Preparation	Analyze and display spatial and temporal data	DOE, HLW, and Center using Geographical Information Systems (GIS) and 3-D modeling	Must have
Analysis Method Preparation	Analyze and make assessments for determinations of whether DOE has adequately demonstrated that a repository can be constructed and operated at a give-site, as required by regulation	DOE, HLW, and Center using Engineering codes, models	Must have
Analysis Method Preparation	"Capture" selected two- and three-dimensional graphics and images (drawings, photographs, video) and incorporate them in written reports or other documents being prepared by the clerical staff	HLW, Center	Must have
Analysis Method Preparation	Flow chart computer programs written by staff and incorporate flow charts and program listings in reports	HLW (No interface)	Improvement

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION (Continued)

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
HIGH-PERFORMANCE COMPUTING (Continued)			
Analysis Method Preparation	Copy into files on the staff's personal computers (PC's) or into the files on mainframe computers used interactively by staff, subsets of numerical physical data from the computer data base files	DOE/Geologic and Engineering Materials: Bibliography of Chemical Species (GEMBOCH), Geographic Information System (GIS), Site and Engineering Properties Data Base (SEPDB), HLW data, Center data, United States Geologic Services (USGS) data, United States Department of Agriculture (USDA) data	Must have
Iterative Performance Assessment	Develop NRC computer codes	HLW, Center, etc., RES, National Laboratories	Must have
Iterative Performance Assessment	Make independent performance assessment evaluations	HLW, Center, RES, national laboratories	Must have
Iterative Performance Assessment	Modify computer programs/codes to meet a particular need or to use on a different computer system	DOE, HLW, Center, RES, national laboratories,	Improvement

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION (Continued)

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
HIGH-PERFORMANCE COMPUTING (Continued)			
Iterative Performance Assessment	Implement the performance assessment methodology	Center, RES, national laboratories	Must have
Rulemaking and Guidance	Check calculations, model predictions, analyses, and data in DOE technical reports and open literature reports	HLW, RES, Center	Must have
DATA BASE ACCESS AND DOCUMENT REFERENCES			
All	Obtain data, manage and manipulate data files, and analyze these data	DOE/GEMBOCH GIS, SEPDB, Center data, USGS data, USDA data, HLW data	Must have
Analysis Method Preparation	Manage and manipulate small to large data bases/files	DOE data bases, Center data	Must have
Analysis Method Preparation	Control and manage existing in-house files of technical references used by the technical staff and provide the associated document management and quality control requirements	HLW/Hydrologic, Technical Reviews, SCP References, Center/Technical Document Index (TDI)	Improvement
Analysis Method Preparation	Access information from in-house files for reference and incorporation in analyses and written reports	HLW	Improvement

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION (Continued)

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
DATA BASE ACCESS AND DOCUMENT REFERENCES (Continued)			
Analysis Method Preparation	Access to and use of existing "out-of-house" reference databases	Various	Improvement[4]
All	Digitize and store information from a printed page for composition of technical reports requiring citation of reference material from printed published papers, letters, etc.	HLW scanning	Must have
Analysis Method Preparation	Use the Licensing Support system (LSS) when it becomes available	Licensing Support System Administrator (LSSA)/LSS	Improvement
Review Plans	Cite document references and incorporate selected information	IRM/NUDOCS, Center/TDI	Improvement
All	Quickly access and use (import text material) reference information and other file information relevant to the review and evaluation of DOE study plans and other site characterization documents and literature	IRM/NUDOCS, LSSA/LSS, Center/TDI, NRC/HLW Document Databases, Open Item Tracking System and the PADB	Improvement
SYSTEMATIC REGULATORY ANALYSIS			
Analysis Method Preparation	Interrogate and extract information from the CNWRA "Program Architecture Support System" (PASS) when making evaluations or preparing technical reports	Center/Program Architecture Data Base (PADB)	Must have

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION (Continued)

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
SYSTEMATIC REGULATORY ANALYSIS (Continued)			
Review Plans	Reference the technical evaluations done under analysis methods and iterative performance assessment	HLW database, Center/PADB, and TDI	Improvement[11]
Report Review	Literature search and report preparation (LARP/PARS)	Center/PADB	Improvement
Rulemaking and Guidance	Access and use the CNWRA PASS data base	Center/PADB	Must have
PROJECT MANAGEMENT			
Management Support	Trend analyses; identify, track, and evaluate trends in the DOE standard deficiencies reports of their quality assurance audits	DOE data bases	Must have
Management Support	Maintain an "Open Item Tracking" system	Center/PADB, HLW/Site Characterization Analysis (SCA)	Must have
Management Support	Prepare PERT charts and make various assessments of staff resources and utilization	HLW/C-3, Center/Commitment Control Log (CCL)	Must have
OFFICE AUTOMATION			
Management Support	NRC intra- and inter- office E-Mail	NRC, Other NRC Offices	Must have
Management Support	CNWRA E-Mail	CNWRA	Must have

Table 2-1. HLW PROGRAM ACTIVITY REQUIREMENTS BY COMPUTER APPLICATION (Continued)

Program Activity Area	Computer Functions and Specific Capability Needed	Organization System/Data Base Interface	Indication of Need
OFFICE AUTOMATION (Continued)			
Management Support	File transfers and file management	NRC, CNWRA, Las Vegas (LV) Office	Must have
Management Support	Prepare high quality printed material using word processing	NRC Las Vegas (LV) Office, Center	Improvement

manipulation software, complex natural system modeling programs, and sophisticated engineering design calculations in the technical reviews of potential radioactive waste sites and facilities.

Extensive interactive modeling and analysis work between the technical staffs of NRC and CNWRA will be performed utilizing capabilities as described above. During the next five years, the following subfunctions are important aspects of technical computing for both organizations. Although applicable to some degree to each of the categories of applications, they are crucial to high-performance technical computing.

- Assurance of model/code accuracy and reproducibility of results for use in technical reviews and the adjudicatory hearing processes.
- Model/Code configuration control.
- User education.
- Maintenance of existing computer systems.
- Management of disk space growth.
- Network bandwidth in NRC/CNWRA connectivity.
- Parallel computing.
- Scientific visualization in multimedia output capabilities.

An analysis was done of the computer functions supporting the designated Program Activities and the Organizations, Systems and database interfaces for each of the five categories of applications. A description of this analysis, including computer capabilities from the 1990 report, in each category is provided below.

2.2.2.1. High-performance technical computing

Analysis method preparation

Significant capabilities are needed in the geologic and other program activities to analyze and display spatial and temporal data. Some of the major system functions to be performed are identified in the following two paragraphs.

Geographic Information Systems (graphical overlays of many sets of spatial data requiring special software and computer hardware to display high-resolution color images) are required. Three-dimensional image construction with rotation and zoom-in and -out to any scale, displayed on high-resolution color monitors is needed to handle the large volume of data accurately and in a timely manner.

Systems to construct geologic stratigraphic and structural features models using such software as: Interactive Surface Modeling (Dynamic Graphics); CPS-1, CPS/FE, CPS/PC (Radian); B/Z-MAP, Z-EDIT, STRATVIEW, Z-CAP, ZDMS, ALAND, ZCL (ZYCOR); CALMA

(GE); IGIS; AGS/880, Applicon 885 Graphics Systems (Ortiz, et al., 1985) are needed. Additionally, systems are needed to correlate different geophysical logs by overlaying different ones; correlate different geophysical surveys (i.e. gravity, magnetic, and seismic); conform digital elevation model data prepared by the USGS with the geologic structure and stratigraphic models developed for a given site or region; calculate and display two and three dimensional plots of data; derive any desired two-dimensional cross-section or three-dimension grid information form the conformed surface topography and subsurface geologic models, for use in numerical flow and transport models; and utilize general visualization techniques.

Capabilities are needed to analyze and make assessments for determinations of whether DOE has adequately demonstrated that a repository can be constructed and operated at a given site, as required by regulation. The following paragraph identifies a variety of system functions to support program activities.

The staff will compile and run a variety of engineering and scientific computer programs (codes) such as: DCM-3D (Sandia), VAM2D (HydroGeologic Inc.), MODFE (USGS), TOUGH, PORFLO-3 (PNL/CNWRA), NEFTRAN-2 (Sandia); construct natural systems models (i.e., geologic structure, topographic, runoff/infiltration, flow, flow/transport, etc.); make assessments of thermal and other pertinent effects in making evaluations of the behavior of components of a waste package; check DOE's designs, which will include analytical methods to evaluate the engineered barrier system (EBS) and the specific waste form that is part of the EBS; prepare complex input files for computer models; display, graphically, computer model results in two and three dimensions; electronically capture and format digital data from printed graphic and text material; digitize maps, charts, and graphs; develop/use artificial intelligence/expert system software; and make statistical analyses and use geostatistical codes and sensitivity codes (regression and adjoin).

In the process of preparing to perform analysis to fulfill program activities, it is necessary for the DHLWM staff to import large technical databases from DOE, USGS, and others. A capability is needed to (i) obtain data, manage and manipulate data files, and analyze these data, and (ii) copy into files on the staffs' personal computers (PCs) or into the files on mainframe computers, used interactively by staff, subsets of numerical physical data from the computer data base files.

DOE databases and files include DOE, Sandia - Site Engineering Properties Data Base (SEPDB), maintained by INGRES, DOE, USGS - Meteorological data base, PC data base; DOE, USGS - Well level records; DOE, USGS - Southern Great Basin Seismic Network data base; DOE, Sandia - Stratigraphic cross-section data, DOE, Sandia - Sorption data (SSDMS II), 3000+ sorption ratios with associated experimental design, water chemistry, and stratigraphic and mineralogical data [dBase III]. DOE, Sandia - Density/porosity data-Yucca Mt. tuffs. DOE, LLNL & NEA -Thermodynamic data base for geochemical model, EQ3/6. DOE, ORNL - Sorption data. DOE, NTS - Meteorological data base; DOE, NTS - Well level data base; and DOE, EG&G - Geographic Information System data.

USGS databases and files include USGS - WATSTORE data; USGS - Digital elevation model data and digital line map data; USGS - Digital geologic map data base; USGS -National Earthquake Information Service data; USGS - Well log data; USGS - Geophysical (gravity, magnetic, seismic reflection and refraction) data; USGS & Others - Satellite image data; and USGS & Others - aerial photographs/video images.

Other databases and files include National Weather Service - Meteorological data; USDA, SCS - Soils data, soils maps; USDA, ARS - Rainfall, runoff, watershed data; Center for Nuclear Waste Regulatory Analyses - Technical data bases; and NRC technical staff data bases.

Iterative performance assessment

Iterative performance assessment requires that the staff have the capability to develop and implement complex scientific codes with appropriate pre- and post-processors. Performance assessment involves the use of a system code and auxiliary analyses. The system code is developed around an executive module that directs the flow of information between different computational modules and controls the sequence of their execution. The computational modules model physical processes such as corrosion of waste packages or transport of radionuclides in the groundwater flow system. The system code also drives the sampling of statistically distributed variables and performs probabilistic analyses of the output from the computational modules to get cumulative distribution functions of the radionuclide release and human dose. The current version of the system code consists of eight computational modules which pertain to statistical sampling, source term, heat flow, liquid flow, gas flow, liquid and gas transport, and dose calculation. Sensitivity and uncertainty analyses are performed by a post-processor on the system code output.

Auxiliary analyses are performed to synthesize raw data into parameters suitable for input to the system code and other physical process codes or to evaluate the capabilities and limitations of the simplified models and codes (e.g. the computational modules of the system code) to estimate performance. Typical auxiliary analyses include 2- and 3-dimensional liquid flow analyses in the saturated and unsaturated zones, reactive transport of gaseous carbon-14, analyses of disruptive events and investigation of sensitivity/uncertainty analysis methods. Essential pre- and post-processors include data base manipulation codes and graphical output codes.

Rulemaking and guidance

Rapid access and use (importing of text) of reference information and other file information relevant to the review and evaluation of DOE documents and other literature is required to support the rulemaking and guidance activities. Calculations, as well as, model predictions, analyses, and data in DOE technical reports and other literature reports must be checked. The Systematic Regulatory Analysis (SRA) process will be employed in the analyses using the CNWRA PASS/PADB to prepare reports.

2.2.2.2. Data base access and document references

The NUDOCS system is the interim system for loading, searching and retrieving full text HLW documents for the DHLWM until the LSS is operational. This system is provided by others. On-line access is required to make this system effective for DHLWM and Center use. A 56 kb leased line is planned between the Phillips and White Flint buildings to accomplish this in FY92.

Technical Document Indexing (TDI) in the Center Library is used for control and retrieval of all hard copy documents, including reports, journals, plans, etc. The Regulatory Information Distribution System (RIDS) documents and technical reports produced and

received by the Center are indexed for retrieval and review by the staff. Technical reviews done by the staff, and others supporting the HLW program and research projects, are loaded and cross-referenced to the appropriate technical documents and interfaced to PASS as document references. The current computerized index contains about 10,000 documents and 90 reviews. The document headers, abstracts and reviews account for about 20 megabytes of storage.

The DHLWM staff will use the Licensing Support System (LSS) when it becomes available to provide the associated document management and quality control requirements for HLW documents, as promulgated by 10 CFR Part 2, Subpart J. It is important to point out that the LSS will not provide the "read-only" access to scientific and technical data bases that will be needed in the technical analyses. The Licensing Support System will not be operational until early FY 1998. At that time loading of all HLW programs documents will begin, most likely on a priority basis, and absorb the documents in NUDOCS for the HLW program during the first year. On-line access is planned for all DHLWM staff.

DHLWM staff will access and use databases containing waste-package data citations and data reviews. This database (previously at NIST) contains over 1000 pertinent citations with abstracts and about 110 data reviews. These numbers are expected to continuously increase to about three times this amount in five years.

There is a requirement to (i) control and manage existing in-house files of technical references used by the technical staff (e.g., the Hydrologic Transport Section file of references [over 700 references on a dBase data base], the file of SCP references and other such in-house reference files at CNWRA and other locations) and (ii) provide all staff with access to information from these files for reference and incorporation in analyses and written reports.

Due to the handling of large volumes of external documents, it is necessary to do document and image scanning. This capability provides digitization and storage of information from a printed page for composition of technical reports requiring citation of reference material from printed published papers, letters, etc.

Access to a number of industry and government databases is required by the DHLWM staff. DIALOG and other on-line library document reference databases, as well as, other databases internal and external to the NRC are examples of those that need to be accessible on the agencies wide-area network.

Most of the DOE and USGS databases needed were cited in Section 2.2.2.1 in the discussion of importing large technical databases for analyses. The NRC/CNWRA will have working technical data bases, e.g. copies of the SEPDB, video tapes, USGS Digital Line Graphics (DLG's) and Digital Elevation Models (DEM's), etc., in addition to distributed interactive use of external data bases at universities, national laboratories, and other sources.

2.2.2.3. Systematic regulatory analysis

The Program Architecture Support System (PASS) is a computer based information system which supports the input, output and storage processes of the PADB which serves as a repository of the information developed through the Systematic Regulatory Analysis (SRA) process. PASS and the PADB document the thought processes by which conclusions were reached

and documented with references in the SRA process. Thus they will be used as an investigative, analytical and management tool. They will play a vital role in the licensing process. Some of the planned products of SRA are defined at this time and more will follow. Currently, identified products include (i) basis for regulatory guidance provided to DOE, (ii) technical basis to reduce regulatory and technical uncertainties, (iii) compliance determinations strategies and methods, (iv) integrated regulatory and technical basis for review of site characterization documents, (v) technical review components and information requirements for license application format and content regulatory guide, and (vi) information needs of a wide and diverse body of users within the NRC and the Center during the licensing and operation of the repository. Although the database is developed by others outside the DHLWM Advanced Computer Review System, this application requires communications support between the DHLWM and the Center for both of their staffs.

2.2.2.4. Project management

The DHLW management requires project schedules, cost accounting and staff planning in a dynamic manner to accommodate changes in the HLW program among the major participants. The DHLWM Operating Plan Status Report is an example of an application that is used by management daily. It is essential that trend analysis and tracking of DOE standard deficiencies reports be implemented. An Open Item Tracking system is being developed by the Center for DHLWM to track the resolution status of regulatory, institutional, and technical uncertainties within the Division of High-Level Waste Management during the prelicensing and licensing phases of a high-level radioactive waste repository. The Center's Commitment Control Log provides the status of all major and intermediate milestones and administrative items planned, and the progress of each. Completed milestones and those awaiting review by the NRC are also tracked. These applications require communications support between the DHLWM and the Center for both of their staffs.

2.2.2.5. Office automation

The office automation requirements are major for the DHLWM in support of all the program activities. Word processing, E-mail and time management are the primary functions requiring computer support. Interoperability with present and future NRC ADP environments and new industry standards is important. The DHLWM needs NRC intra- and inter-office E-mail and file transfer capability. The same capability is needed with the CNWRA and the NRC Las Vegas office. The AUTOS implementation is designed to meet these requirements and is described in Section 3.2 of this report.

2.3. PROJECTED DHLWM SYSTEM AND NETWORK USERS

The information from the requirements analysis of program activities and computer functions needed to support them was further analyzed for a five-year period to project the number of DHLWM staff users in Table 2-2. The estimated DHLWM staff users for the system and network has been projected in the columns in Table 2-2 for each of the five computer application categories. Within each application category the selected organization, system, and database interfaces identified in Table 2-1 and described more fully in the preceding subsection that represent non-overlapping user access requirements have been used as rows in Table 2-2.

For example, in regard to internal organizations the DHLWM user interfaces with the Office of General Counsel (OGC), RES, and others are considered primary. The Center, the NRC site

office at Las Vegas, and the national laboratories, such as Idaho National Engineering Laboratory (INEL) and Los Alamos National Laboratory (LANL), are considered the primary external (network) organization interfaces. In regard to specific systems and data bases, High-Performance computing and AUTOS will be primary for internal and external office automation processes and technical computing for the DHLWM staff. The database access file transfers and document referencing applications will involve NUDOCS, ultimately the LSS, Center and DHLWM document files, and other internal and external data bases for technical information. The link to the Center in San Antonio and the Center's Washington Technical Support Office are important for office automation, data base access, project management, SRA and the PADB, as well as High Performance Scientific and Engineering computing using some of the more than 45 codes the Center has under configuration management and control. In addition to accessing the Center, the national laboratories and others, the DHLWM is anticipated to implement and use its own high-performance computing workstations for extensive computations in support of Iterative Performance Assessment (IPA), Geologic, Hydrologic, and Engineering projects as described in Section 2.2.2.1.

Therefore, the projected number of DHLWM users in Table 2-2 includes the DHLWM staff members at both White Flint and in their on-site office at Las Vegas that are projected to be users of the applications. Both High-Performance Technical Computing and AUTOS networks are considered to be available to these users. This information is necessary for designing the appropriate level and configuration of software and hardware systems to support the program during FY93-97 and developing an integrated DHLWM advanced computer review system (NRC EDO, 1991a).

Table 2-2. PROJECTED DHLWM USERS AND INTERFACES FOR FY93-97

Organization System/Data Base Interfaces by Application Category	Projected DHLWM Users by Fiscal Year				
	93	94	95	96	97
HIGH-PERFORMANCE COMPUTING:					
Analyze and Display/Plot Spatial/Temporal Data Using GIS/Silicon Graphics Iris (SGI) in color (DHLWM, Center, LANL, INEL, others)	10	12	14	16	18
Analysis Using Engineering/Scientific Codes (DHLWM, Center, LANL, INEL, others)	20	22	24	26	30
Database access and analysis (DOE and contractor data bases)	10	12	16	16	18
PA Methodology and IPA (DHLWM, Center, LANL, INEL, others)	16	20	22	24	26
Rulemaking and Guidance Support (DHLWM, Center, LANL, INEL, others)	20	22	24	26	30

Organization System/Data Base Interfaces by Application Category	Projected DHLWM Users by Fiscal Year				
	93	94	95	96	97
DATA BASE ACCESS AND DOCUMENT REFERENCES:					
NRC/NUDOCS	58	60	62	65	68
Center/TDI	4	4	5	5	6
LSSA/LSS	-	-	-	-	20
DHLWM/Technical Document Reviews	4	4	4	4	4
DHLWM/Geologic/Hydrologic	6	6	6	6	6
DHLWM/Electronic Document Scanner (Text and images)	20	22	24	26	28
Other external data bases (DIALOG, etc.)	10	12	14	17	20
SYSTEMATIC REGULATORY ANALYSIS:					
Center/PADB	37	39	42	45	45
PROJECT MANAGEMENT:					
DHLWM Operating Plan Status Report	6	6	6	6	6
DHLWM/Trending DOE audits	-	6	6	6	6
Center/Open Item Tracking	13	13	13	13	13
Center/Commitment Control Log	6	6	6	6	6
OFFICE AUTOMATION:					
DHLWM/Work Plans (WP), E-mail, file transfers	58	60	62	65	68
Research/E-mail, file transfers	4	4	4	4	4
Office of General Counsel (OGC)/E-mail, file transfers	2	2	2	2	2
Center/E-mail, file transfers	37	39	42	45	45
Las Vegas Office/E-mail, file transfers	6	6	6	6	6

2.4. MAJOR PROGRAM MILESTONES FOR IMPLEMENTING THE DHLWM ADVANCED COMPUTER REVIEW SYSTEM

The major program milestones that can be identified at this time have been listed in Table 2-3 so that they can be ordered in the most appropriate sequence to permit an integrated implementation

based on the priority needs. It is envisioned that the Center project team will meet with DHLWM staff and project officers to refine this schedule before design begins on the system. Further details on these major program milestones, and the personal computer, workstation and network configurations for an integrated system to support the staff are provided in Section 3.

Table 2-3. MAJOR PROGRAM MILESTONES FOR IMPLEMENTING THE DHLWM ADVANCED COMPUTER REVIEW SYSTEM

Date	Milestone
August 1990	Report on "DHLWM Computer Hardware and Software Functional Needs and Some Proposed Specific Needs" was delivered by NRC DHLWM
May 1992	Report on "Functional Needs Update and Status Report on the DHLWM Advanced Computer Review System" (To be delivered (TBD) by CNWRA)
July 1992	Report on "Design and Implementation schedule for the DHLWM Advanced Computer System for Technical Review" (TBD by CNWRA)
September 1992	High Performance Computing Network and Workstations with communication links to AUTOS and WAN to Center, Research, and Internet to INEL and LANL by IRM based on Center design
FY93/94	Continue to upgrade High-Performance Computing Network based on design and implementation schedule and lessons learned

3. COMPUTER CONFIGURATION CAPABILITIES AND REQUIREMENTS

This section discusses computer capabilities and requirements for the DHLWM. It is broken down into three subsections: (i) Current Capabilities; (ii) Planned Capabilities; and (iii) Additional Capabilities Needed. The first subsection discusses the capabilities for computing in the DHLWM at the time of this report. The second subsection discusses the functionality that is planned to be implemented in FY92 as part of the separate AUTOS initiative. The final section discusses some additional capabilities needed and references Appendix A which discusses a proposed integrated system environment that would meet the DHLWM technical computing needs while making optimal use of the current and planned capabilities discussed in the preceding two sections.

3.1. CURRENT CAPABILITIES

The DHLWM operates a mixture of Personal Computers (PCs) of widely varying performance capabilities (see Table 3-1). The low-end machines powered by 8088 and 80286 microprocessors (the most numerous) are capable of performing single tasks in the areas of Office Automation, Document Referencing, and access to Systematic Regulatory Analysis (SRA) work using the Program Architecture Support System (PASS). The high-end machines powered by 80386 and 80486 processors provide the minimum level of computer power necessary to utilize engineering codes and models.

The PCs also have a wide range of hard disk storage capacities ranging from none (IBM PCs) to 10/20/30Mb (IBM XTs, ATs and PS/2-30's, respectively) to 40Mb (Compaq 286s) to 100Mb or more (Compaq 386 and Zeos-486). The PS/2-30's also have the limitation that all, except a couple that have been upgraded to 640K, only have 512K RAM. Also, only the 486 and Compaq 386's have math co-processors. The current disk capacities are generally capable of supporting word processing and other office automation tasks. Only the larger drives are sufficient for scientific computing, and accessing DOE data bases and storing data sets from other investigator's models would overtax the present levels of storage. While implementation of a LAN (see next section) will lower the amount of local storage needed by allowing files to be stored on a file server, moving data sets will require large amounts of local storage on a temporary basis.

At the present time, 13 of the DHLWM PCs are configured with 3270 coaxial connections and 3270 terminal emulator software to connect to the NRC IBM 9370 and the Southwest Research Institute (SwRI) IBM 4381. These PCs support the SRA requirement. Connectivity with other computers, such as at the national laboratories, National Institutes of Health (NIH), NUDOCS, and CNWRA workstations is limited to dial-up access using a modem and a terminal emulator, such as Crosstalk XVI or Smarterm 400. Telephone dial-up at 2.4 Kbs or 9.6 Kb is adequate for occasional file transfers, but unusable for transfer of the 50-300Mb data sets commonly associated with many models. The DHLWM has not implemented a LAN at this date.

In summary, the DHLWM's PCs represent "islands" of computing capability with widely varying capability, no internal (within the division) connectivity, and limited external connectivity.

Table 3-1. NRC DHLWM EXISTING PERSONAL COMPUTERS

Quantity	Description	Microprocessor
1	IBM PC	8088
25	IBM XT	8088/80286
1	IBM AT	80286
2	Compaq 286	80286
14	IBM PS/2 -30	80286
1	AST	80286
2	NEC SX/20	80386 SX
1	IBM PS/2 -70	80386
6	Compaq 386/20	80386
1	Zeos 486/33	80486

3.2. PLANNED AUTOS CAPABILITIES

The NRC has a plan to provide office automation functionality and agency-wide connectivity as part of its AUTOS initiative (Gianios, 1991). It provides three major areas of improved functionality for the DHLWM: (i) a minimum level of PC capability to support office automation requirements; (ii) a division LAN with file, print, backup, and agency-wide E-mail services; and (iii) Wide Area Network (WAN) connectivity functions within the agency and to the outside world, including 56 Kbps to the Center. Each of these areas are discussed in further detail below.

3.2.1. AUTOS Minimum PC Capability

As part of the AUTOS replacement of the IBM 5520, PCs will be upgraded to a minimum level of function necessary to support the LAN interface and word processing software. The AUTOS design document specified a minimum XT class machine configuration (Gianios, 1991). Implementation experience may show that a more powerful PC (e.g., Intel 386) is required. Regardless, this minimum level machine must be capable of operating the office automation software required in the AUTOS design: WordPerfect 5.1, WordPerfect Office, Lotus 1-2-3, Crosstalk XVI, and PC-DOCS. Standardization on a software set and the minimum computing power necessary to run those in conjunction with the LAN will greatly simplify computing complexities across the agency.

CNWRA experience with LAN implementations has shown the minimum level of PC suitable for office automation tasks (DOS, LAN, 3270 communications, and WordPerfect 5.1) to be a

386SX machine with 4Mb of memory. PCs with 80286 processing have speed and stability problems when working in WordPerfect to perform pagination or table creation tasks while printing across the LAN. Therefore, the DHLWM may need to consider upgrading more of their PC's than are currently planned with AUTOS in FY92.

3.2.2. AUTOS Local Area Network (LAN)

The AUTOS LAN implementation will link the DHLWM PCs into a Token Ring LAN using Novell Netware. The LAN will provide printer support in the approximate ratio of one printer per twenty-five users. The Novell File Server (Intel 486 class machine) will have tape backup support to archive user files. Each Token Ring LAN will have a mail server supporting WordPerfect Office mail functions. In addition, one mail server will provide connectivity for E-mail between WordPerfect and PROFS and UNIX mail systems for the whole building.

Each Token Ring LAN will be connected to a router. This router will transfer packets to LANs on other floors and building (all part of the AUTOS and WAN; see Section 3.2.3). In addition, the router will transfer packets to other WANs destinations, such as CNWRA and the Internet. Also, the router will provide Token Ring to Ethernet conversion, as needed.

As part of the support of AUTOS, IRM will provide Network Management Functions for the LANs. These functions include workstation configuration and maintenance, network administration, training, software and hardware trouble shooting, file and print server maintenance, mail server configuration, Transmission Control Protocol/Internet Protocol (TCP/IP) address assignment and maintenance, security maintenance, and wide area connectivity and maintenance. These services will be provided by help, both "on-floor" and from an AUTOS network control center.

3.2.3. AUTOS and the Wide Area Network (WAN)

As mentioned in Section 3.2.2, each AUTOS Token Ring LAN will be connected to a router to provide WAN access. All NRC offices will be connected to one another via 56 Kb data lines in a Wide Area Network (WAN). In addition to NRC offices (White Flint, Nicholson Lane, Phillips (NUDOCS), and the Regional Offices), routers will be placed at NIH (to provide Internet access), at the CNWRA in San Antonio and at the Center's Washington Technical Support Office (WTSO) in Arlington, VA. (see Fig. 3-1). This will provide direct LAN-to-LAN connectivity to both CNWRA locations, as well as TCP/IP access to any Internet site, including Idaho National Engineering Laboratory (INEL) and Los Alamos National Laboratory (LANL) supercomputing facilities.

3.2.4. AUTOS Support

The goals and objectives for AUTOS are: (i) replace the 5520 systems; (ii) establish agency-wide connectivity; and (iii) design a base platform to access current and future NRC applications (Gianios, 1991). AUTOS is designed to improve technology and serve primarily as an administrative network with engineering application connectivity via TCP/IP. With the exception of connectivity, it does not provide the functional needs identified for high-performance technical computing. The network management support for AUTOS will include LAN administration and a network control center.

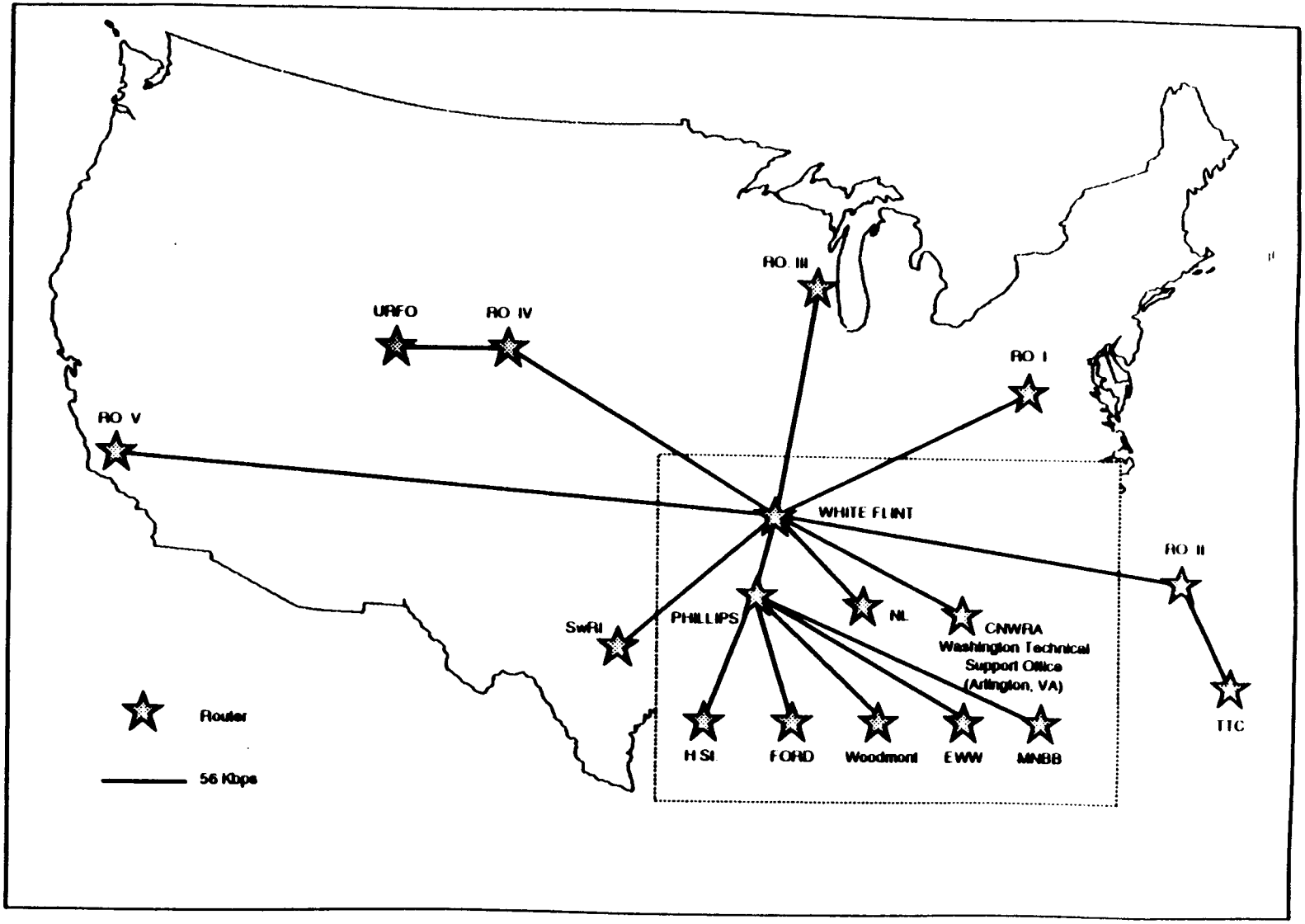

Figure 3-1a. NRC Agency Wide Area Network (WAN)

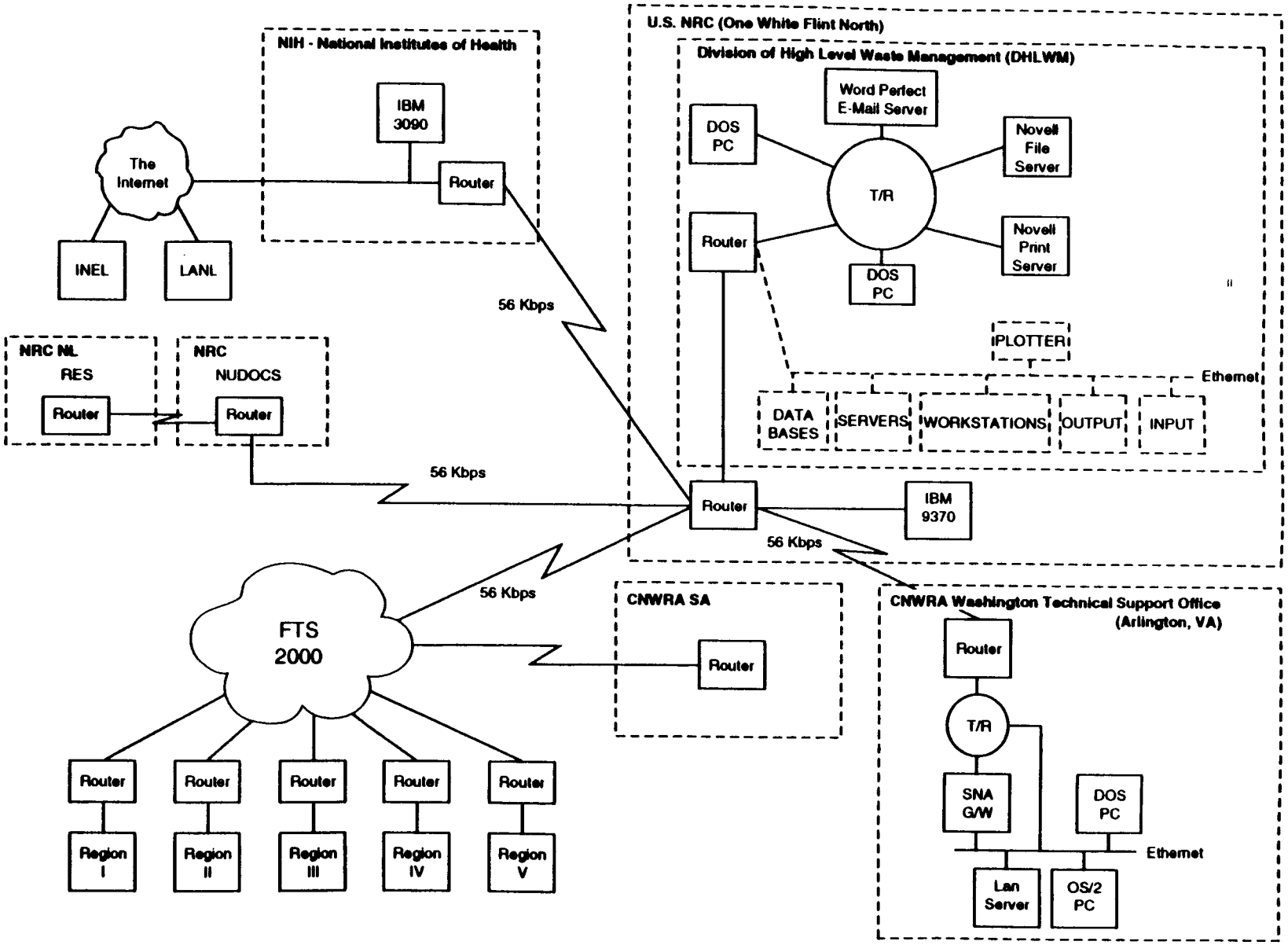

Figure 3-1b. DHLWM and WTSO relationship with AUTOS and the WAN

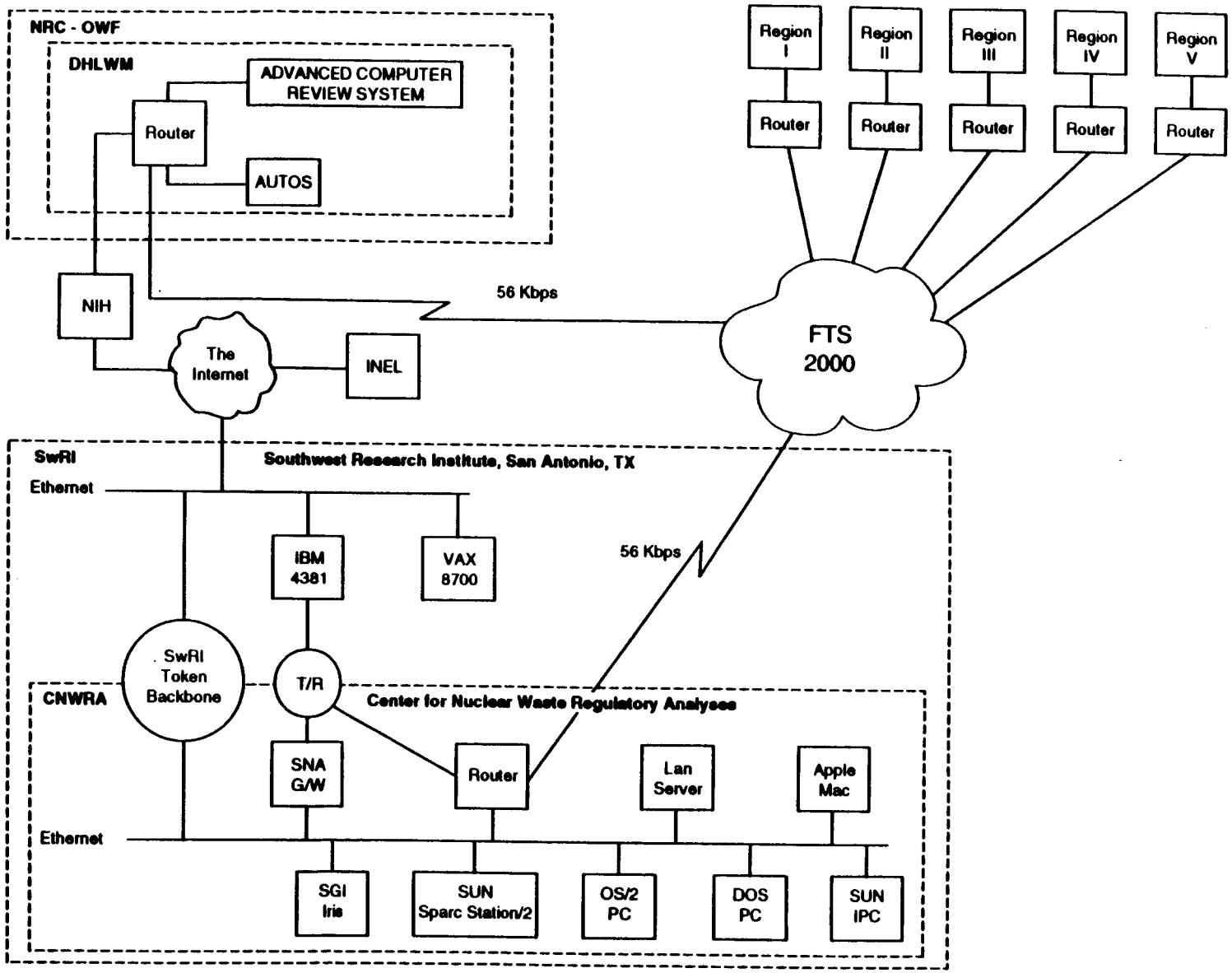

Figure 3-1c. CNWRA San Antonio office relationship with AUTOS and the WAN

The LAN Administrator will support administration of user accounts, coordination of installation and removal of all network components, maintain all LAN documentation, provide trouble-shooting and problem resolutions, and provide on-site user support.

The network control center will be responsible for performance monitoring and tuning, problem/fault management, configuration management, LAN administration support, and network management software. All of the AUTOS support will be provided by the NRC Office of Information Resource Management (IRM) separate from the DHLWM Advanced Computer Review System initiative.

3.3. ADDITIONAL CAPABILITIES NEEDED

The proposed integrated system environment in Appendix A addresses the needs for an integrated DHLWM Advanced Computer Review System as defined in Section 2 of this report. It is provided as part of this report to indicate the type of computer processing, calculation, graphics, file management configuration and connectivity capabilities that need to be considered during the design phase (Subtask 2). A summary of the additional capabilities is provided below.

AUTOS has been designed to provide basic office automation as mentioned in Section 1.3. However the computer application areas of High-Performance Technical Computing and Data Base Access (see Table 2-2) require computer capabilities beyond what has been acquired to date and planned for implementation in AUTOS. These additional capabilities include greater computing (calculational) power, access to specialized computers (super and parallel-processing computers), program (models and codes) development, specialized graphical data display and manipulation, file and data sharing, and others. Based on survey results to date and pending discussions with NRC management, it appears that the following types of computer hardware and software will be required to meet the identified functional needs as stated primarily in Section 2.2.2.1 and 2.2.2.2:

- High-performance computer workstations to provide calculational capabilities, program development capabilities, and graphical display/manipulation capabilities. These functional needs may be best met by placing at least one workstation in a central common area as the computational server for the network, for occasional use by all staff and team projects. Other high-performance computers would be located with individual staff based on frequency of use and overall need for the functional capabilities offered by such workstations.

- High-performance computer workstations to provide central storage, backup, print and password (administrative) services for all computers and all input and output devices on the technical review network. This will allow the users needing the graphics capabilities of the workstation to access their programs and data files at any of the workstations, because those files will be stored on the server, not on a particular workstation.

- UNIX appears to be the operating system of choice for the high-performance computers for the DHLWM Advanced Computer Review System.

- Implementation of the TCP/IP communications protocol on user PCs so that they may communicate from their PCs across the LAN to the UNIX workstations and

other NRC computers and across the LAN to CNWRA computers and computers on the Internet.

- Implementation of the Network File System (NFS - usually part of a TCP/IP implementation) on user PCs so that they may access files on the UNIX workstations just like local PC files (a major advantage of the NFS protocol).

- Upgrade existing or acquire new PCs with computational power capable of running the TCP/IP and NFS software, the AUTOS office automation software, and small to medium size models and codes designed to run on the PC platforms.

- Ancillary hardware and software for input and output such as scanners, printers, compact disk drives, video tape drives, etc. with needed software drivers and utilization programs.

This architecture provides several levels of computing power to match the identified functional requirements mentioned in Section 2.2.2.1 in an effective and efficient manner. Connectivity is provided to allow access to all of the computing environments (internal and external to DHLWM) and supporting functions mentioned in Section 2.2.2 from the user's PC.

4. SUPPORT, TRAINING, AND ON-GOING FUNDING

4.1. SUPPORT

One of the major assumptions made in Section 1.4 is that adequate support for the UNIX high-performance technical computing will be provided by IRM. It is envisioned that this support will include procurement of the system based on DHLWM designs, installation of system and integration of all necessary commercial hardware and software products and services with the end-user application.

Operations and maintenance of a network made up of several high-performance computers with peripheral devises and twenty or more PCs is a task requiring perhaps two full-time, well-trained individuals. While vendor installation and support is very helpful for physically placing a new computer on the network, there are a number of tasks that need to be performed to integrate the new computer into the network. Likewise, there will be an ongoing need to investigate and test software and hardware upgrades, so that maintenance does not adversely impact staff utilization. Back up procedures must also be designed and implemented rigorously; a needed, but missed backup is worse than no back up at all. The level of complexity for administration and application support of UNIX systems demands that this be done in order for the system implementation to be successful.

The Center Information Management System (IMS) staff could be used to monitor the implementation, to define new requirements, and to provide design and support services as necessary. Such support could be developed following the design phase of this task.

4.2. TRAINING

So that the DHLWM Advanced Computer Review System is used effectively and efficiently, there will be a need for staff training on the functioning of the system and some of the installed special software. There is the possibility of training DHLWM staff by participation in special courses at INEL and LANL. The Center will provide ongoing workshops, seminars, and training for NRC staff as part of the center's overall program and more specifically for Performance Assessment and Research Projects. IRM will need to provide training for the UNIX system operation and maintenance staff supporting DHLWM users. Training should include the UNIX operating system and all related functions, as well as familiarization with products and services required to support technical computing for DHLWM.

4.3. FUNDING

Funding is a constraint on the system design. Thus for the design phase of this Task, the IRM budget shows $300K for FY93 and $600K for FY94, and an additional $385K has been requested by reprograming for FY92 to address the Commission's request to accelerate advanced technical computer capabilities in the agency. In order for the system to be productive, ongoing funds must be available to procure specific software packages and modify workstation configurations to meet the evolving requirements. An estimate of a needed on-going funding level will be made at the end of the design phase.

5. CONCLUSIONS

In conclusion, the following major points were confirmed during the review and others will be resolved during the design and ongoing implementation of the computer capabilities.

5.1. POINTS CONFIRMED IN THIS REVIEW

5.1.1. Program Requirements Update

Based on analysis and discussions of the 1990 report, the survey and current status of DHLWM plans the following points were confirmed in this review.

- Assumptions in Section 1.4 that have been made are sound and have been minimized to the extent possible.
- Information in Table 2-1 is a correct statement of the program activity requirements and computer functions with indication of need.
- Information in Table 2-2 is the best projection of DHLWM system and network users each year.
- Schedule of major program milestones in Table 2-3 is integrated and detailed to the best level possible at this time for a viable plan.

5.1.2. Computer Configuration Capabilities and Requirements

The analysis of existing, planned and additional computer configurations and capabilities confirmed the following points in this review.

- Number and configuration of existing PCs have been confirmed.
- Plans for upgrade/acquisition of PCs for AUTOS LAN implementation have been confirmed.
- Schedule and configuration information for Agency WAN connection between One White Flint North (OWFN) and the CNWRA in San Antonio, and between OWFN and the CNWRA Washington Technical Support Office in Arlington, VA.
- Schedule and configuration information for High-Performance computing connectivity to AUTOS and the WAN.
- Schedule and configuration information for NUDOCS connectivity to NRC WAN at White Flint.

5.2. POINTS THAT WILL BE ADDRESSED DURING THE DESIGN

5.2.1. Computer Configuration Capabilities and Requirements

The computer configuration capabilities and requirements that will be resolved during the design are as follows:

- Type, number and configurations of PCs.
- Type, number and configuration of UNIX graphical workstations.
- Use of a UNIX server and its configuration.
- Communication protocol for connectivity between PCs and UNIX workstations.
- Speed of telecommunications line between White Flint and CNWRA (56 Kbps or 1.544 Mbps (T-1)).
- Specification of software for system operation.
- Specification of software for technical computing support.
- Recommendations for DHLWM existing document reference data bases, project management and SRA applications.
- Specification of input and output hardware with appropriate drivers and operating software.
- Communications protocol for connectivity to external data bases.

5.2.2. Recommendations for Support, Training and On-going Funding

The support, training and on-going funding points that will be addressed are as follows:

- Recommendations for necessary and adequate support for the DHLWM Advanced Computer System and UNIX high-performance workstations.
- Recommendations for training programs for DHLWM end-users of UNIX workstations.
- Recommendations for necessary long term funding.

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APPENDIX A

PROPOSED INTEGRATED SYSTEM ENVIRONMENT FOR THE DHLWM ADVANCED COMPUTER REVIEW SYSTEM

PROPOSED INTEGRATED SYSTEM ENVIRONMENT FOR THE DHLWM ADVANCED COMPUTER REVIEW SYSTEM

Due to widely varied computer requirements throughout the DHLWM, the following sections of this document address a generic hardware architecture which, if implemented, would provide a flexible computer base allowing systematic, phased expansion and providing a computing environment amenable to most software identified in the functional requirements review.

Due to the diverse nature of the work conducted within the Division, many varying software packages have been identified. As a result, no single hardware solution will provide all the answers. Additionally, one of the most basic requirements for all respondents was improved office automation capabilities (e.g. word processing). The NRC's AUTOS project will address many of the PC hardware requirements that were identified. However, the AUTOS project does not adequately address the connectivity requirements from a PC to remote computers (e.g. supercomputers, UNIX Workstations, etc.) Many of the software packages identified also require a UNIX based workstation; as a result, the discussion that follows is an implementation plan that will establish a computing network within the DHLWM which will provide both DOS and UNIX support platforms so that a wide variety of user requirements can be met. Additionally, connectivity requirements/features will be addressed so that an AUTOS PC could be utilized to access non-AUTOS computers.

The next three sections address the hardware configurations in a general sense, with emphasis on the long term capabilities of the recommended architecture. The concluding section recommends the order in which equipment should be procured so that the recommended architecture is constructed in a manner which allows maximum flexibility as the system is purchased (i.e. make maximum use of available funding).

Connectivity

The AUTOS network is a Novell based network (physical connection is through a token ring) which communicates through the use of IPX data packets. Typically, UNIX operating systems are TCP/IP based networks (physical connection is through ethernet). Routers and Bridges have the capability to inter-connect the two types of physical media to allow interchange of data packets (as long as the software protocols are consistent). The best solution for the DHLWM would be to add TCP/IP capability to each AUTOS workstation (achieved by adding software to each workstation) so that the AUTOS workstations can communicate utilizing the TCP/IP and IPX protocols. By implementing TCP/IP on all of the DHLWM PCs, staff members could connect to any of the computers on the network supporting TCP/IP from their PCs (refer to Figures 3-1a, b, and c in Section 3.2.3) of main report.

UNIX Environment

With the varied requirements of the potential UNIX users within the DHLWM, the optimal approach would be to establish a UNIX server (with no graphics capabilities for user interface) and then add UNIX clients (i.e. workstations) as funds become available and additional functionality is required.

UNIX server

A server based UNIX network has many advantages over simply procuring workstations and "tying" them together. Most important, a server provides a central focus for shared resources (e.g. disk space, print service) which will minimize the redundant purchases which would otherwise be required if only individual UNIX workstations were procured (e.g., multiple UNIX workstations can share a single printer). It is important to understand that a server is not required to share UNIX resources, however, from a UNIX system administration perspective it is the most cost-effective solution. Many organizations have started out buying UNIX individual workstations (without a server) and then quickly learned that a UNIX server was vital to establishing a workable environment.

A server should be established as a dedicated resource with no plans to use the server as a workstation (i.e. no graphics support should exist on the server). Secondary use of a server as a workstation will degrade its performance and, as the load demand on the server increases, the effectiveness of using it as a workstation will diminish as well.

A significant advantage of establishing a good UNIX server is that it can be used to serve a variety of vendor workstations. This implies that a good Sun server could provide network services to Sun workstations, Silicon Graphics, Hewlett Packards, etc. Additionally, a well designed UNIX server can also provide various services to a PC workstation (such as an AUTOS workstation).

The following is a list of services and capabilities that a good, robust UNIX server should provide:

- File service: Numerous studies and experiences have shown that the most cost effective method of providing disk storage is to provide a central pool of disk space that is accessed by multiple users. This allows a reserve of disk space to always be available. Additionally, a system administrator can evaluate overall disk requirements by simply monitoring a single server (as opposed to having to look at individual machines).

  Establishing a central file service also has the following benefits:

  - Users can access their files from any UNIX workstation (or PC if appropriately configured) attached to the network -- this implies that a person can have mobility in the work environment.

  - A central repository for commercial software can be established. By placing software on the server, several individuals can have access to it, which should reduce the number of copies required by an organization and should correspondingly reduce software costs.
  - Shared data files can be maintained so that if users are sharing output data or developing software, they can work from the

same set of data files (duplicate data files will invariably get out of synchronization and cause problems).

- Backup service: All data on the server should be on a nightly backup schedule so that in the event of user error or hardware failure, no more than a day's worth of data would be lost.

- Print service: A high-speed printer should be attached to the server. The printer should support various software protocols (i.e. Postscript, HP PCL, ASCII) so that various applications (both UNIX and DOS based) can spool their output to the printer.

- Mail service: UNIX has powerful mail capabilities which allow people throughout the world to communicate in an integrated fashion. Many PC networks have gateways into the UNIX mail capability so that mail can be freely interchanged between UNIX and the PC network.

- Yellow Pages: A concept of "yellow pages" has evolved in the UNIX community and is now supported by most major UNIX vendors. "Yellow pages" is a centralized system administrator tool which provides a variety of features. Two of the most notable are (i) password service (so if you change you password on a Sun workstation your password will automatically be changed on ALL workstations on the network -- even those of different vendors) and (ii) "name" service (which allows users to access remote computers/users through ASCII names rather than specific computer addresses).

The establishment of a good UNIX server is not a trivial task, a significant amount of initial setup work is required to assure that all services are appropriately established. Additionally, a UNIX server will not operate on a day-to-day basis without some level of system administration and supervision. A system administrator will need to be identified and this person will need to manage the UNIX server on a daily basis.

UNIX client

If the UNIX server is correctly established, a UNIX client can be procured from a variety of sources. It is assumed that most UNIX clients will have graphics capabilities and minimal hard disk requirements. The amount of memory required is directly related to the type of applications to be executed by the user of the workstation. In a well-designed environment, the UNIX client workstation will have the following software resident on its local hard disk:

- Operating system: the operating system and its associated files (e.g. swap space) should be contained on the local disk to minimize the network traffic generated by operating system requests and services.

- Disk I/O intensive applications: should be maintained on the hard disk because retrieving data from a local hard disk is significantly faster than retrieving the data from a server over a network. A good example is X-

windows; this software has many different font files which are accessed as screens are manipulated.

Note that user data and shared applications should be maintained on the server so that users can access the data from various locations. Additionally, if dynamic information (that which changes) is kept only on the server then the requirements for backing up the client systems are minimized.

DOS Environment

Assuming that the AUTOS network will be installed and operational, this section addresses the software that should be added to the AUTOS workstations to allow them to interact with the UNIX server (which will then provide the server capabilities such as electronic mail, data exchange between PCs and UNIX workstations, etc.).

The connectivity requirements can be accomplished by the implementation of two software packages. The first package will be PC resident (on an AUTOS workstation) and will allow access to the UNIX environment. The second software package will be resident on the Novell server and will allow the UNIX workstations to access capabilities of the Novell server. The following two subsections detail the functionality provided by these two software packages.

Novell LAN WorkPlace

Novell markets a product called LAN WorkPlace which implements TCP/IP for a Novell NetWare based client. The product co-exists with the Novell NetWare software (which implies that the basic functionality of the AUTOS system is fully intact) while providing the following additional capabilities:

- File transfer: The LAN WorkPlace product implements FTP (File Transfer Protocol) which is a utility to allow the transfer of files from TCP/IP based computers (i.e. other PCs as well as UNIX workstations). The FTP feature will allow an AUTOS workstation user to transfer files between a PC and a UNIX workstation/server (while NetWare provides the capability to transfer files between a PC and the Novell server).

A very user friendly "point and click" environment (i.e. graphical interface) is provided to simplify the file transfer process.

- Terminal emulation: Allows access to remote hosts through Ethernet using the industry standard Telnet approach. This implies that an AUTOS workstation could directly connect to any TCP/IP capable computer attached to the DHLWM LAN (i.e., when the Internet is attached to the DHLWM LAN, access to remote hosts in other geographical areas can be accomplished).

- Remote file printing: Files from a LAN WorkPlace based PC can be printed on UNIX devices. This implies that a plotter could be attached to a UNIX platform and accessed from an AUTOS PC.

- Remote program execution: The LAN WorkPlace software will allow a PC NetWare based user to initiate programs on a remote UNIX platform. This implies and AUTOS user can initiate tasks on remote workstations (i.e. CPU intensive applications can be remotely spawned).

- Supports a variety of TCP/IP networking applications: A LAN WorkPlace PC can execute many vendor's advanced software packages such as X-Windows, Oracle, SYBASE, etc.

- Software compatibility: The LAN WorkPlace software can be used in conjunction with popular multi-tasking environments such as Microsoft Windows and Quarterdeck's DESQview/386.

The LAN WorkPlace software will co-exist in memory with the NetWare ODI network drivers and utilize less than 45 KB of conventional RAM (RAM in the 0 to 640 KB addressing range) while requiring and additional 16 KB of extended (or expanded) memory to load the IPX and NetWare shell software. The software drivers for LAN WorkPlace can be loaded/unloaded without rebooting the computer.

Novell NetWare NFS

Novell markets a product called NetWare NFS (Network File System) which provides UNIX workstations with transparent access to the NetWare operating system. The software executes on the Novell Server and allows any NFS client, such as the UNIX workstations described earlier) to share files and printer services from the Novell server.

Specific capabilities provided by the NetWare NFS software package include:

- File transfer capability: Allows any UNIX client to "mount" file services (i.e., access a file system as a logical disk) from the NetWare server. This will allow the transfer of files from the UNIX client to the NetWare server. The software will allow files on the Novell server to be treated as "UNIX" files (with appropriate file attributes and naming conventions) to the UNIX user.

- Print service: The UNIX client can submit print jobs to any NetWare print queue (which implies printers/plotters can be shared between Novell and UNIX users).

- File locking: Allows files to be "locked" so that only a single user may access the file at any time. This is useful when multiple individuals are sharing data files.

The NetWare NFS software is loaded and resides on the Novell NetWare server. This software requires that the server utilize NetWare v3.11 or above and that the TCP NLM in NetWare v3.11 be loaded and running. No specific UNIX client software is required (i.e. the NFS support is provided by the vendor of the UNIX workstation and will already be a part of each UNIX client system).

Recommended Hardware Plan

With the AUTOS project coming on-line and being integrated into the DHLWM in FY92, it appears appropriate to direct current funds at two major areas:

- PC environment:
  - Procure Novell LAN WorkPlace for some numbers of AUTOS PCs so that the connectivity can be evaluated.
  - Procure Novell NetWare NFS software to be installed on the AUTOS Novell server.
  - Common output devices such as plotters and printers should be attached to the AUTOS Novell server so that all AUTOS and UNIX users will be able to access these devices.
- UNIX environment:
  - A UNIX server should be procured so that basic UNIX services can be made available. The server should be a Sun SPARCServer with 32 MB of RAM, a 4 mm DAT (Digital Audio Tape) backup device, and at least 1 Gigabyte of disk capacity.
  - UNIX workstations should be procured with available funds to provide UNIX capabilities to those requiring them.

It is important that these basic functions (which require both hardware and software) be installed immediately so that incremental additions of hardware and software can be integrated into a cohesive environment. It is much more difficult and much less effective to first procure many independent components and then attempt to integrate their functionality at some point down the road.

APPENDIX B

GLOSSARY

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3270 Terminal Emulator	Software to allow a PC or Workstation to communicate with an IBM mainframe by mimicking a 3270 terminal.
Bridge	A set of computers that connects, or bridges, two LANs together. On each LAN the bridge examines each packet to see if it is addressed to the other LAN; if so, the packet is passed across the bridge to the other LAN.
CISC	*C*omplicated *I*nstruction *S*et *C*omputer - A computer architecture using a Central Processing Unit that can perform a large number of commands. Generally operating on a large number of data types (e.g. Integers of varying lengths, Multiple Floating Point Formats, Packed Decimal, Zoned Decimal, etc.), CISC computers are frequently implemented as simple execution hardware and a layer of microcode that emulates the complicated instructions used at the system and user software layer.
Client	A computer that requests some service from another computer.
Ethernet	A media (cabling) transport protocol in which a packet of information is broadcast both directions on the cable to all other computers which listen for transmissions directed to it. Since only one computer can transmit successfully at a time, if two computers attempt to do so the packets collide; each of the two computers then wait a random delay time before attempting to retransmit. Any communication protocol (such as TCP/IP, Novell IPX/SPX, IBM SNA, etc) can be carried on the ETHERNET media layer.
File Server	A computer dedicated to storing and retrieving files for another computer (the requestor) on the network.
FTP	*F*ile *T*ransfer *P*rotocol - A protocol (part of the TCP/IP protocol suite) used to transfer files between two computers.
GIS	*G*eographic *I*nformation *S*ystem - A database system that links data about an area in space with a graphical representation, such as a map, of that space.
GUI	*G*raphical *U*ser *I*nterface - Software that provides a windowed presentation of the programs and data on the computer. A pointing device like a mouse allows manipulation of objects, such as icons, that represent programs and data.
Internet	A collection of computer networks interconnected across the world. Uses TCP/IP as standard protocol.

LAN	*L*ocal *A*rea *N*etwork - A group of computers connected together by cabling, hardware (Network interface card) and software so that they may communicate using one or more communication protocols. A LAN is generally limited to a single floor or building based on signal dissipation in the cables used.
Mail Server	A computer dedicated to provide electronic mail (e-mail) services to a network. Usually those services include sending e-mail to the destination computer when it is ready to receive it, storing mail when the destination is not ready to receive it, resolving nicknames to computer addresses, and conversion to foreign mail system's format.
Network File System	A protocol providing for the sharing of files between two computers on the network. One computer exports (shares) a disk drive to one or more remote computers. Those remote computers can mount or attach that exported drive and the NFS software will make that exported drive look like a local drive to that remote computer. For example, a UNIX computer may export a disk with multiple subdirectories; a DOS computer with NFS will access those UNIX files as files on a DOS drive.
Packet	The smallest unit of transmission across a network. A file is divided into packets based upon the maximum packet size of the transmission protocol and each packet is sent separately. Usually each packet contains the address of the computer sending the data, the address of the destination computer, a sequential packet number (for packet order), and error recovery information (e.g. checksum). The receiving computer reassembles the packets, requesting retransmission of any packets that were not received correctly.
PC	Personal Computer - Low capability computer. Usually powered by an Intel 80X86 (IBM compatible) or Motorola 680X0 (Apple) processor. Limited graphics capability.
Print Server	A computer dedicated to accepting and printing files for other computers on the network.
Protocol	A set of conventions for communicating between multiple computers on a network.
RAM	*R*andom *A*ccess *M*emory - High speed, non-permanent storage for programs and data that the Central Processor works on. Everything in RAM must be loaded and stored back to secondary (permanent) storage, such as disk or tape.
Remote Execution	The ability to run a program on a remote computer without having to logon to that computer. TCP/IP provides two such protocols: RPC (*R*emote *P*rocedure *C*all (RPC) and REXEC (*R*emote *EXEC*ution).

RISC	*R*educed *I*nstruction *S*et *C*omputer - A computer architecture using a Central Processing Unit that can perform a small number of simple, fast commands operating on a limited number of data types (e.g. Integers and Floating Points only).
Router	A specialized computer that routes packets of data to their destination. Attached to multiple communications lines, a router examines each incoming data packet to determine its destination and retransmits the packet on the communications line leading to its destination. If the format of the incoming packet is incompatible with the outgoing communications line, the packet is reformatted appropriately (e.g. from Ethernet to Token Ring).
Server	A computer dedicated to providing some service (files, printing, backup, communications, etc.) to other computers on the network.
Service	A distinct task that one computer (the server) can provide for another computer on a network.
TCP/IP	Transmission Control Protocol/Internet Protocol - A collection of protocols or methods of encoding information to be transmitted across a network. Arising as a *de facto* standard from the work on ARPAnet and later the Internet, it is comprised of the protocols for file transfer (FTP - *F*ile *T*ransfer *P*rotocol and TFTP - *T*rivial *F*ile *Transfer* *P*rotocol), terminal emulation (Telnet), mail transfer (SMTP - *S*imple *M*ail *T*ransfer *P*rotocol), network management (SNMP - *S*imple *N*etwork *M*anagement *P*rotocol), and others.
Telnet	A protocol (part of the TCP/IP protocol suite) providing terminal emulation. Generally, a set of terminal types are supported (DEC VT-52, VT-100, VT-220, IBM 3270) allowing the user to logon to a remote computer across the network.
Token Ring	A media (cabling) transport protocol in which all the computers are connected in a ring. A signal (called the token) is passed around the ring. A computer can transmit only when it has the token and the token is empty. If the token contains a packet (is not empty) the computer passes the token on, and waits until the next receipt of the token to transmit. Any communication protocol, (such as TCP/IP, Novell IPX/SPX, IBM SNA, etc) can be carried on the token ring media layer.
User	A human being located at one computer.
WAN	*W*ide *A*rea *N*etwork - A collection of LANs that may span very long distances (across the globe). LANs may be connected using bridges, routers, modems, fiber optic cable, leased telephone lines, microwave links, satellite links, packet switched networks, etc. WANs may communicate using more than one communications protocol, with

protocol conversion being accomplished by hardware (multiprotocol routers) or software (bridge software).

Workstation — Low to intermediate capability computer. Usually having advanced graphics capability.

X-Windows (or X) — A protocol providing remote display of graphics. The program computing the problem and the graphics runs on one computer. That computer sends the drawing commands to the other computer which displays them to the user.