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REVIEW AND ANALYSIS OF THE PASS/PADB SYSTEM FOR SYSTEMATIC REGULATORY ANALYSIS

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1 INTRODUCTION

This report documents a functional review of the Program Architecture Support System/Program Architecture DataBase (PASS/PADB) system and the subsequent analysis of the system requirements. It is primarily conceptual in nature, intending to establish a basis for a more detailed follow-on design and development document.

2 REVIEW OF PASS/PADB VERSIONS 1.0 AND 2.0

During the last five years, the approach to Systematic Regulatory Analysis (SRA) and the Program Architecture (PA) has undergone a number of changes in response to redefinition of program needs by the NRC. These changes, which continue at this time, have affected the development and implementation of PASS/PADB and have necessitated two major revisions to the system. Developments during FY92 and FY93 have further impacted the design and implementation of PASS/PADB and the role that it is expected to play in support of the Nuclear Regulatory Commission (NRC) and Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs as they focus on the production of the License Application Review Plan (LARP). The intent of this functional review of the PASS/PADB system and its role in support of SRA is to clarify the steps in the evolution of PASS/PADB which were represented by Versions 1.0 and 2.0 and to propose a revised approach to meeting current and future requirements.

2.1 STRUCTURE AND CONTENT OF PASS/PADB

PASS/PADB was conceived as an integral part of the PA and its original implementation was designed to support data types and information structures derived from the 22-step PA process. The proof-of-concept for the PASS/PADB of the system and database supporting the PA was accomplished in April 1, 1988 (Johnson, 1988a). Version 1.0 of PASS/PADB contained a limited example of all the data records from the PA, from Regulatory Requirements (RRs) through Information Requirements (IRs), as these records were then defined. Relational links between the various PASS elements and the Technical Document Index (TDI) system were also demonstrated. Thus, the implementation of Version 1.0 of PASS/PADB on December 1, 1988 provided a proof of system (Johnson, 1988b), demonstration of the capability of the relational database, and confirmation of the concept of the PA.

The following three significant changes occurred in the underlying concepts of PASS/PADB prior to the implementation of Version 2.0:

- Technical Review Components (TRCs) were introduced to specify the information to be provided in the License Application (LA) in support of "what" the Department of Energy (DOE) needs to provide for compliance demonstration. TRCs were expected to have parallel elements in the Compliance Determination Methods (CDMs) to indicate "how" compliance would be determined. Thus, the original nature of PASS/PADB changed to a structure of parallel hierarchies with cross-linkages between corresponding elements.

- TOP-001-02 (Program Architecture Relational Database Work Instruction) formalized the content of records corresponding to the entire 22-step PA Process, and this definition forced increased complexity of PASS/PADB with correspondingly complex methods of presenting information to the user (Romine, 1989).

- Analysis of logic interrelationships among the Regulatory Elements of Proof (REOPs) and TRCs was formalized, and logic diagrams were added to the system to clarify relationships and permit the user to "navigate" among data elements with a pointing device (mouse).

Version 2.0 of PASS/PADB was successfully implemented and demonstrated for RRs, REOPs, Regulatory Uncertainties, TRCs, CDSs and CDMs. The complexity of the data structures and the level of effort required to generate and enter information required by TOP-001-02 resulted in only the RRs, REOPs, and Regulatory Uncertainties being loaded into the database. Technical Uncertainties (UNs), Information Requirements (IRs), and Open Items (OIs), along with a wide variety of records relating to the analysis and evaluation of alternative programs, were not fully developed or loaded. Even as the implementation of PASS/PADB Version 2.0 was being undertaken, the CNWRA and NRC were beginning to move away from the execution of the complete 22-step PA Process as a requirement underlying PASS/PADB. Instead, only steps 1 through 15 of the PA Process were to be implemented using PASS/PADB and SRA document formats were significantly simplified. The redefined focus became the development of the LARP.

2.2 TOP DOWN ANALYSIS FROM REGULATIONS TO INFORMATION REQUIREMENTS

The original conceptual basis for the PA called for an extensive and logical top-down development of requirements, uncertainties, and alternatives through rigorous analyses which began with the RRs. Considerable emphasis was placed on work processes and program control. Therefore, PASS/PADB Version 1.0 was based on a hierarchical organization flowing downward from RRs. The intent was to work toward clear and early identification of RRs and their associated REOPs, Regulatory Uncertainties, Technical Uncertainties, and IRs. Great emphasis was placed on Regulatory Uncertainties and their reduction because of their potential impact on the entire program and NRC's unique role in their resolution. It was believed that when all technical uncertainties and IRs had been identified and described through the top-down analyses, a relatively small number of consolidated Uncertainties and IRs would be identified which would impact broad areas of the repository program. Thus, the PA and PASS/PADB were seen as powerful tools which could be used to identify key areas for research, allocate scarce resources more efficiently, and ultimately shape the direction of the repository program. Version 2.0 of PASS/PADB was an extension and elaboration of the features of Version 1.0 which were designed to implement this concept. Version 2.0 introduced parallel hierarchies between RR/REOP/TRCs and the CDS/CDMs. The added structural complexity was intended to support the identification and consolidation of Uncertainties and IRs so that alternative programs and resource allocations could be evaluated.

However, the level of effort required to produce the analyses combined with the differing perspectives of the CNWRA and NRC management and staffs led to a decision to move away from the evaluation of alternative programs which was originally to be incorporated in steps 14-22 of the PA Process. Thus, much of the conceptual basis and rationale underlying Version 2.0 of PASS/PADB changed and the immediate value of the information which had already been loaded became uncertain. The NRC staff independently developed a separate RR structure as represented in the Draft Format and Content Regulatory Guide (FCRG), and this structure was accepted for use by DOE in developing annotated outlines of the License Application. This necessitated revision of the RR structure which had been developed by CNWRA.

2.3 EMPHASIS ON SUPPORT FOR THE HEARING PROCESS

During the period when Versions 1.0 and 2.0 of PASS/PADB were being designed and implemented, the effort focused on "ultimate users" of the system (the legal and technical staffs supporting the LA technical reviews and hearings). All reporting and regulatory products developed prior to the hearings represent a data structure which can be used to guide the repository program and support the information needs of the technical review and hearing staffs. This perspective on the "ultimate users" of the system was very helpful in identifying and defining long-range needs of the system. However, it is now clear that the requirements of such "ultimate users" cannot currently be well-defined, while the requirements of near-term users among the NRC and CNWRA staffs are comparatively clear. While PASS/PADB will undoubtedly prove necessary to those involved in the hearings, there has been an increasing emphasis on providing more immediate support to the NRC and CNWRA staffs in the production of such regulatory products as the LARP. This changing focus on the current requirements for PASS/PADB is reflected in the revision of the RR structure to match the FCRG, the elimination of TRCs as SRA products, and the increased emphasis on using PASS/PADB in development of the LARP.

2.4 EMPHASIS ON CORPORATE MEMORY

The retention of "corporate memory" is a fundamental goal of PASS/PADB and the PA. Because of the great complexity and long duration of the repository program, it is clear that there will be considerable turnover of staff at both the NRC and CNWRA during the life of the project. PASS/PADB is to serve as the "corporate memory" for the repository program by keeping an enduring record of rationales for actions and decisions, references to confirm decisions and support analyses, and also conclusions which were reached as the repository program evolved. Therefore, TOP-001-02 placed a great deal of emphasis on rationales, references, comments, and observations, and this emphasis was reflected in the implementation of PASS/PADB. However, the level of effort to develop and maintain the extensive rationale and comment records envisioned in TOP-001-02 has been judged to be beyond the level of resources available. Also, an NRC concern emerged about the indefinite retention of materials which reflect changing or even conflicting views on an issue during the predecisional period because of the potential value of such material to intervenors during the hearings. As a result, the number and complexity of these records is being reduced. Nonetheless, "corporate memory" remains an important design objective even though the organization and structure of PASS/PADB is changing.

2.5 ORGANIZATION OF THE FORMAT AND CONTENT REGULATORY GUIDE (FCRG) AND DATA ORGANIZATION OF PASS/PADB

It was originally expected that PASS/PADB would be able to provide major support for the production of the FCRG because compliance demonstration in TRCs derived from the aggregate of the RRs and REOPs should encompass everything required for the License Application. However, several factors combined to cause the FCRG to be produced with a format which did not correspond to the records and data relationships developed by the CNWRA and placed in PASS/PADB. The NRC produced a draft of the FCRG, the structure of which reflected the regulatory, technical and organizational intent and perspective of the NRC. This resulted in a disparity between the FCRG and PASS/PADB. The draft FCRG became the basis for DOE Draft Annotated Outlines for the LA. This left PASS/PADB somewhat misaligned with the ongoing efforts which would ultimately lead to the production and review of the LA. Following the publication of the draft FCRG, an effort was undertaken to reorganize the RRs and retitle them Regulatory Requirement Topics (RRTs) which replaced RRs so that they would conform to the

FCRG. The resulting RRTs were no longer aligned, in terms of content and data relationships, with the Version 2.0 PASS/PADB data.

2.6 DIFFICULTY PREPARING AND LOADING WORKED EXAMPLES OF PASS/PADB RECORDS

In the process of implementing PASS/PADB Version 2.0, the difficulty of creating and loading "worked examples" of the data was encountered repeatedly. TOP-001-02 was developed, reviewed, and commented upon. During implementation of PASS/PADB Version 2.0, a number of difficulties with the record contents and relationships were identified and corrected. However, because of other priorities and the level of effort necessary to prepare and validate input data, PASS/PADB Version 2.0 was not developed to its full extent and existing records were not kept current with pertinent and meaningful data. This was compounded by comments from the staffs concerning complexity in operating the system. Consequently, the NRC and CNWRA staffs did not become active and enthusiastic users of the system. This led to complications in achieving full definition and proof of the system concept. The lesson learned is that, it is important to scope and focus future development efforts so that any new or upgraded system is available in a timely manner and the data is produced and loaded into the system quickly enough to be of value in meeting the needs of the NRC and CNWRA staffs.

2.7 DIFFICULTY GETTING AGREEMENT ON THE CONTENT OF PASS/PADB RECORDS

During the initial implementation of PASS/PADB Version 1.0, there was great concern for the technical quality of the materials being loaded. To address this concern the Program Architecture Review Committee (PARC) was established and tasked with performing reviews of all materials prior to loading them into PASS/PADB. The review process slowed the data preparation and loading processes. The PARC did not fully achieve the intended result because the NRC staff and management found some of the material unacceptable. Part of the problem resulted not from the PARC but from the degree to which the personnel producing the materials for PASS/PADB were working in isolation from both the NRC and CNWRA technical staffs. More recently the use of joint development techniques between the CNWRA and NRC staffs been more fully adopted for the production of regulatory products such as the LARP. This approach should produce early agreement on the technical content of PASS/PADB materials and should make it possible to load the system with truly useful and important information at an early stage in its implementation.

2.8 THE NEED FOR AN ALTERNATIVE APPROACH TO IMPLEMENTING PASS/PADB

In the foregoing discussion of the evolution of PASS/PADB, a number of changes in system requirements have been identified along with revisions in system implementation resulting from these changes. The frequency of fundamental changes in requirements reflects the nature of an evolving system where there is difficulty in establishing clear objectives which can be met through implementation of system functionality. This difficulty in closing on requirements is reflected in several factors which have combined to frustrate previous attempts to implement the PASS/PADB system as discussed in the previous sections. One of the most important lessons to be learned from the experiences of Versions 1.0 and 2.0 of PASS/PADB is that the users and the system developers must ensure that they have reconciled differences between system capabilities and what users are actually able and willing to use. An overall

long-range design for the system that makes adjustments for lessons learned is desirable and is needed in the long term. However, the past inability to sufficiently identify and refine the long-term needs, suggests that PASS/PADB system design and implementation should focus on meeting short-term needs while retaining flexibility for the long term.

The difficulty of implementing PASS/PADB Versions 1.0 and 2.0 and the lack of user acceptance of these systems was also related, in part, to the limited availability of "off-the-shelf" packages and software tools which could supply the needed functionality. During the last four years, however, great progress has been made in software technology and many "off-the-shelf" tools and packages are now available which can be integrated with custom code to achieve a more functional and "user-friendly" system. Therefore, future development of PASS/PADB should concentrate on utilizing "off-the-shelf" software tools and packages wherever possible (e.g., document transfer facilities, data management tools, and text management capabilities) which can be integrated and adapted to meet specific user needs. Many such tools and software packages are available today on more "user-friendly" network environments. The NRC and CNWRA should determine which of these tools meet their needs and contribute significantly to the development of SRA products. Economic functionality should be incorporated into PASS/PADB by installing "off-the-shelf" system components and only designing and implementing custom code when appropriate "off-the-shelf" components are not available. It is important that any such system components be flexible and adaptable so that they can be applied again and again to develop and refine limited system functionality which addresses currently perceived needs of the NRC and CNWRA management and staffs.

Unlike the original plan for PASS/PADB, some applications such as the Open Item Tracking System (OITS) are being implemented incrementally as NRC needs arise and perceptions of requirements evolve. This approach is very promising because it permits the system to adapt and respond to changing programmatic and institutional requirements. Such an iterative approach to system implementation is more likely to achieve user acceptance and desirable long-term results than embarking on complete long-range designs which expand beyond the currently defined needs of the NRC. Thus, an alternative approach to PASS/PADB development is needed in which the system design is evolved as requirements are clarified, and changed when those requirements are modified. Major priority at this time should be given to applications which support immediate near-term requirements and regulatory products. However, this must be done with a clear understanding of the user's needs, capabilities, and environment.

3 CHANGED SYSTEM REQUIREMENTS FOR PASS/PADB

3.1 RETHINKING AND SIMPLIFICATION OF SRA DATA AND DATA RELATIONSHIPS

Recently, the thinking about the data scope, requirements, and the format and content of PASS/PADB has undergone a number of changes which reflect a desire to simplify SRA data and data relationships. Among these changes in the content and organization of PASS/PADB was the elimination of TRCs as separate records. The information which would have appeared in the TRCs in PASS/PADB Version 2.0 is now consolidated within individual sections of the FCRG. In the revised PASS/PADB it is still possible to examine this information in relation to its associated CDMs provided such a need is recognized and implemented. Many of the data fields such as Related Regulations, Rationale for Inclusion, and Statutory Basis, which were prominent in the Version 2.0 RRs have been eliminated in the new RRTs at the request of NRC to reflect evolving program needs. The reporting formats, which are still evolving, have also been simplified and streamlined. All of these changes indicate a new focus on simplified input and output formats and more immediate support of near-term regulatory products.

3.2 EMPHASIS ON THE ROLE OF PASS/PADB IN SUPPORT OF THE PRODUCTION OF THE LICENSE APPLICATION REVIEW PLAN (LARP)

The immediate, near-term objective of producing SRA products in support of the LARP has become a primary goal of PASS/PADB. To this end, the data in the Version 2.0 RRs and REOPs were combined and regrouped to match the organization of the FCRG, and considerable effort is being applied during FY93 by NRC and CNWRA staff working as groups to produce CDSs which will be part of the individual review plans in the LARP. Much of the planned work for FY94 is directed toward producing CDMs which will also become portions of the individual review plans. Thus, for the next several years the production of the LARP will be the primary SRA activity, and much of the information loaded into PASS/PADB will be LARP-related.

3.3 EMPHASIS ON NRC/CNWRA WORKING GROUPS IN THE PRODUCTION OF THE LARP

The NRC and CNWRA have adopted a working group approach to the production of SRA products in support of the LARP in which staff members from both organizations work jointly to perform specific analyses. Along with this change in approach, there has been an increased involvement of technical staffs in the production of SRA products and the LARP. This has necessarily affected the work process and user requirements for PASS/PADB. In this working group environment, the NRC and CNWRA staff members must communicate and interact to produce a common work product. Therefore, PASS/PADB must provide some measure of support for this environment including capabilities for electronic exchange of evolving work products and document and version control mechanism.

3.4 CHANGE IN THE REQUIREMENT FOR AN IBM MAINFRAME IMPLEMENTATION

The original direction from the NRC was to utilize an IBM mainframe in order to maintain compatibility with the NRC. Current direction encourages a more "open system" architecture operating in a network-based environment. PASS/PADB Versions 1.0 and 2.0 were implemented on the IBM 4381 mainframe using a leased line to connect NRC Division of High-Level Waste Management (DHLWM) users via the NRC IBM 9370. The slow response time of the system, including the necessary graphical user interface for Version 2.0, was particularly noticeable in the NRC's White Flint North facilities due to the speed of the 9.6 kB communications line which became a limiting factor and further degraded performance. In addition to slow response time, the mainframe only supported the outdated technology of "unintelligent" page-mode terminals. Therefore, it was not possible to provide users with the high level of interactivity which they had come to expect when working with PC applications.

A decision to permit implementation of PASS/PADB in a network-based environment means that much of the computer-intensive processing requirements, data entry, and data presentation support can be spread among the users' personal computers and workstations while the common processing requirements such as support for the text repository and the relational database can be accommodated on a high performance server machine. This, in conjunction with enhanced communication facilities between the CNWRA and NRC, should greatly improve the responsiveness of the system. The shift to a network-based system environment would have the added advantage of making it possible for the user to interact directly on the personal computer or workstation for input guidance, editing, validity checking, and "Help" support. Rather than a fixed sequence of menus, the system will be able to support the more sophisticated and user-friendly software technologies which the users have experienced in other PC-based applications.

3.5 NEED FOR FLEXIBILITY TO ADDRESS EVOLVING SYSTEM REQUIREMENTS

Many of the requirements for PASS/PADB are still evolving, and significant impact on data relationships and reporting requirements can be anticipated in the future. Therefore, the computer/interface system (hereafter referred to as the "system") must be implemented in a way that maximizes flexibility and modularity so that changes can be accommodated without significant disruption to system use and performance. This suggests that a new focus on near-term goals should be adopted which corresponds to the revised thinking and approach to SRA as a whole. Emphasis should be placed on production of near-term products while building system structures, facilities, and tools which will permit the system to adapt and respond to evolving future requirements. The shift toward a network-based system which can be efficiently and compatibly integrated into the developing computer support systems at the NRC and CNWRA is a very positive step. There is an obvious need to integrate any revised PASS/PADB into the developing computer systems at the NRC and CNWRA. Such a network-based system will contribute significantly to achieving the longer-term requirements for flexibility and adaptability, because system functionality will be modularized and isolated between "client" facilities such as the user interface, data entry, and presentation of results, and "server" facilities such as management of the textual data repository and relational database. Therefore, the impact of future changes in system requirements should be localized to a degree which will permit them to be addressed with minimal impact and disruption to the users.

4 SYSTEMS ANALYSIS

Following the review of PASS/PADB, which established changes in requirements due primarily to program evolution, a system analysis was accomplished. Using a classic systems approach to PASS/PADB, the system objectives were defined, needs delineated, and alternative solutions composed. Information was derived from interviews and meetings at both the NRC and CNWRA, and from correspondence and published reports from both organizations. Because of the size of the affected staffs, no attempt was made for completeness. Instead, through interviews with a cross-section of the staffs at the NRC and CNWRA, characterization of the PASS/PADB was sought. To help ensure an efficient, economical, and appropriate design and implementation process, the near-term analysis focused on four specific goals, and a philosophy of flexibility was used to address the uncertainty associated with medium-term and long-term goals.

4.1 SYSTEM OBJECTIVES

Four system objectives were defined for PASS/PADB:

1. Assist in the Production of SRA Products.

2. Aid in the Construction of the LARP.

3. Provide a Viable System for Future Developments.

4. Function in a Network-Based Environment.

Cost effectiveness is an implied objective and is broken out for separate treatment in a life cycle cost analysis of the alternatives. Objectives 1 and 2 are the most obvious and important goals which the PASS/PADB must support. Objective 1 includes assisting in revision of RRTs, production of CDSs, and in the coming years production of CDMs. Objective 2 includes the mechanical combining of portions of the SRA products in an efficient fashion to provide for annual update and publishing of the LARP. Objective 3 addresses the flexibility, expandability, and portability of the PASS/PADB structure and content to provide for the ability to efficiently incorporate format and content changes and posture the system for additional implementation of features when the need arises as the HLW program progresses and evolves. Objective 4 focuses on the need for the PASS/PADB to be integrated into the currently developing computer support systems at both the NRC and CNWRA. These currently developing systems are network-based in contrast to earlier centralized mainframe-based processing systems.

4.2 SYSTEM NEEDS

The pertinent needs which are derived from the objectives are as follows:

1. Textual Data Repository. The system must provide a well organized repository for textual data and word processing documents.

2. Full-Text Search and Retrieval. The system must provide a means of searching full-text documents for specific words, phrases, and topics of interest.

3. Data Management. The system must provide mechanisms for managing the data and controlling access and update privileges by storing additional information about the records and their relationships and access limitations.

4. Word Processor Access/Compatibility. The system must provide access to compatible word processor capabilities from all workstation platforms.

5. Message/File Transfer Capability. The system must permit efficient and user-friendly transfer of files with associated messages between all workstation platforms.

6. System Response Time Performance. The system must exhibit fast response time for all commonly performed functions.

7. Minimize Impact on Computer Support Plans. The system must not cause major adverse impacts on existing and planned computer systems and equipment configurations.

8. Compatibility with Upgrade Initiatives. The system must be compatible with existing and planned upgrades of equipment and processing applications both at the NRC and the CNWRA.

9. Growth Potential. The system must support orderly growth to larger configurations and expanded capacities.

10. User Interface. The system must present an interface to the user which is logically structured and easy to use.

11. Economic Cost. (Considered separately under life cycle cost).

The next step in the systems analysis is to relate the objectives to the needs using tri-state diagraphs (Sage, 1977).

Table 1, there shows the heavy support for the short-term goals of SRA product preparation and constructing the LARP by satisfying virtually all of the needs. The additional system considerations expressed in needs 5, 6, 7, 8, 9, and 10 support the longer-term objectives 3 and 4.

4.3 SYSTEM ALTERNATIVES

Generic alternatives were constructed which cover options from updating the current mainframe-based system to new components integrated into the respective organizations' current network-based systems. Four generic representative hardware and software alternatives are considered below.

1. Upgrade Current Mainframe. Requires the updating of the relational database structure and loading of current data, as well as improving the communication capability of the IBM 4381 system. Because of this technology, certain needs (see Table 2) would be only partially satisfied and the cost would be significant (see Section 3.4).

TABLE 1. ANALYSIS OF SYSTEM OBJECTIVES AND SYSTEM NEEDS.

SYSTEM OBJECTIVES / SYSTEM NEEDS	Assist in the Preparation of SRA Products	Aid in Construction of the LARP	Provide for a Viable System for Future Developments	Function in a Network-Based Environment
1. Textual Data Repository	X	X	/	/
2. Full-Text Search and Retrieval	X	X	X	/
3. Data Management	X	X	X	/
4. Word Processor Access/Compatibility	X	X	X	/
5. Message/File Transfer Capability	X	X	X	X
6. System Response Time Performance	X	X	X	X
7. Minimize Impact on Computer Support Plans	/	/	/	X
8. Compatibility with Upgrades Initiatives	/	/	X	X
9. Growth Potential	X	X	X	X
10. User Interface	X	X	X	X

X Need is HIGHLY supportive of objective.

/ Need is MODERATELY supportive of objective.

0 Need provides LITTLE OR NO support for objective.

2. Procure the Use of a New Mainframe. Requires procuring of the use of a more modern mainframe and the design and integration of the necessary software functions to satisfy as many of the needs as possible. Because of the difficulty of integrating this application into the NRC and CNWRA network-based systems, certain needs (see Table 2) would be only partially addressed.

3. Procure a Balanced Distributed-Database Processing System. Composed of a network-based, distributed-database, text repository and processing environment. In this alternative, the existing PCs and workstations would share the software, processing overhead, and storage of relevant data. An "open system architecture" implementation is envisioned which brings the hardware and software under a "standards" program administered by national and international standards organizations in order to maximize future expandability, flexibility, portability, and vendor independence. This alternative involves significant potential problems. If the storage data is distributed over multiple PC's or workstations, a number of difficulties may arise in maintaining the integrity of the data and controlling access to it. Therefore, a more conservative approach is preferred in which the storage and control of the data is localized in a central database server which is shared by all users. This permits more direct and positive control of data integrity as well as control of access to information in the database.

4. Procure a Client/Server Based System. Similar to Alternative 3 in that the open system architecture applies. However it differs in that a LAN workstation/server is procured to hold a centralized text repository and relational database. This server also runs portions of the database and text search software to address the established needs. The server accomplishes the majority of overhead processing allowing the other PCs and Workstations (clients) to operate in a higher throughput mode. The client/server version of the network-based system has the additional advantage of providing the fastest system response. No significant weakness are evident with this option.

Similar to the previous analysis done with the objectives, relating the system needs to the alternatives was accomplished with the aid of an interaction matrix. As shown in Table 2, the network-based alternatives dominate the centralized processing mainframe alternatives.

4.4 LIFE CYCLE COSTS

The life cycle cost (LCC) of the alternatives introduces the necessary pecuniary dimension. Present net value calculations are used as the basis for this LCC analysis. The LCC analysis is shown in Figure 1 for Alternatives 1 and 4. Alternative 1 dominates from a cost perspective the two mainframe options, being only a fraction of the initial cost and annual operating expenses of Alternative 2, where besides the very high hardware costs, the database development cost is also needed. Therefore, Alternative 2 is eliminated from further consideration because it is viewed as being too expensive. Alternatives 3 and 4 are very comparable in cost, but Alternative 4 dominates the network-based alternatives from the data control, data management, and performance perspectives. Therefore, because Alternative 3 is technically dominated without having an economic trade-off, it was eliminated from further consideration.

Assumptions used in the LCC analysis include:

1. Any hardware or software currently in place for both the NRC and CNWRA is a sunk cost not considered in this LCC analysis.

2. An interest rate of 6 percent is used for time value calculations over the life of the system (1993-2001).

3. Required initial update/upgrade cost for the IBM 4381 mainframe includes (a) an effort of fifteen person-months to modify the database structure, load the data, and upgrade the graphic capability ($225K), and (b) software costs for text processing enhancements ($80K). Technology upgrading is assumed to occur every two years. This amounts to 60 percent of the initial cost (PASS/PADB's portion of the CNWRA's mainframe cost). PASS/PADB's prorated proportion of user costs for an expected level of use is $168K per year. Because of volume increases in data stored, the use charge increases at 10 percent per year.

4. Procure/install cost for the Client/Server network-based system is based upon off-the-shelf software and commercially available hardware. This includes procuring a LAN server and supporting software ($180K), installing software, designing and developing the text file and database structures, and loading data (10 person-months - $150K). An

TABLE 2. ANALYSIS OF NEEDS AND ALTERNATIVES.

NEEDS / ALTERNATIVE	1 Textual Data Reposit ory	2 Full-Text Search & Retrieval	3 Data Manag ement	4 Word Processor Access / Compatibi lity	5 Message / File Transfer Capability	6 Systems Response Time Performance	7 Minimize Impact on Computer Support Plans	8 Compatibil ity With Upgrade Initiatives	9 Growth Potential	10 User Interface
1 UPDATE CURRENT MAINFRAME	/	/	X	/	/	0	0	0	0	0
2 PROCURE USE OF A NEW MAINFRAME	/	/	X	/	/	/	0	0	0	0
3 PROCURE A BALANCED DISTRIBUTED DATABASE PROCESSING SYSTEM	X	X	0	X	X	/	/	X	X	X
4 PROCURE A CLIENT / SERVER NETWORK BASED SYSTEM	X	X	X	X	X	X	X	X	X	X

X Alternative is HIGHLY supportive of need.

/ Alternative is MODERATELY supportive of need.

0 Alternative provides LITTLE OR NO support for need.

industry standard 20 percent maintenance/use cost is assumed for each year, and a 30 percent technology upgrade cost is assumed every two years to incorporate structural changes and implement new features in the network-based system (percentages are functions of the initial costs in FY93), (Gibson, 1990).

5. In FY2001, there will be a retirement cost at 25 percent of the initial costs for retiring or refurbishing the system.

6. All costs pertain to system modifications at the CNWRA. Additionally each alternative requires less than $25K for implementation at the NRC. Therefore this amount is eliminated from LCC considerations.

The cost streams for both alternatives are shown in Figure 1.

The present values of cost streams for 1993-2001 are $2,429,000 for the mainframe (Alternative 1) and $1,094,000 for the client/server system (Alternative 4).

Considering both the cost analysis and the technical performance of the client/server Lan-based system over the mainframe, it is straightforward to recommend migrating off the mainframe to a network-based system implementing a Client/Server architecture.

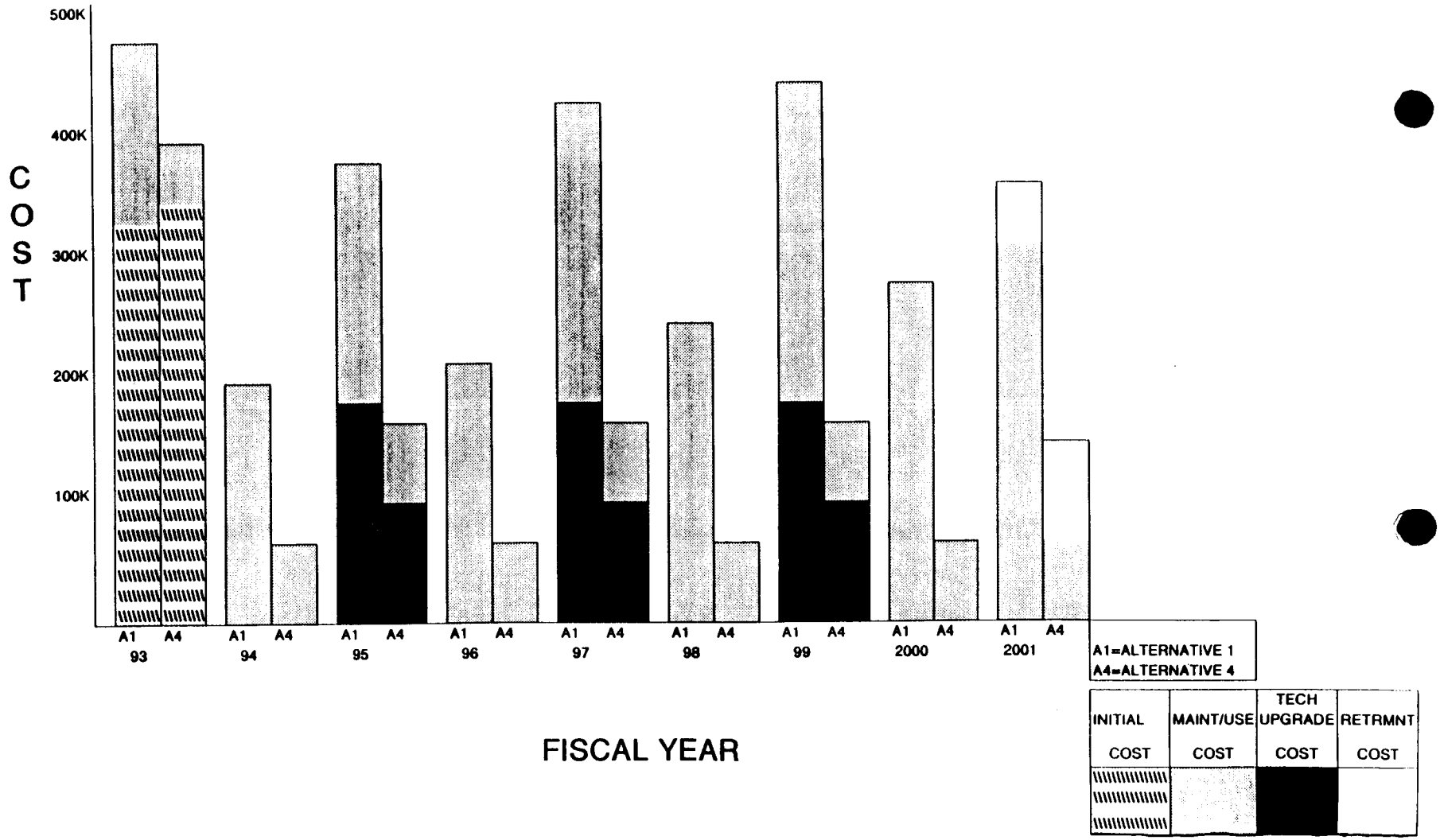

Figure 1. LIFE CYCLE COST STREAMS

5 PASS/PADB FUNCTIONALITY

The needs established in the systems analysis step lead naturally to future PASS/PADB functional definition. While described at a general level, the direction for the PASS/PADB can be visualized. Detailed delineation will comprise a subsequent design and development document.

The requirement to support the LARP in the summer of 1993 is a near-term objective which will require certain system functionality, capacity and support. Longer-term system capabilities in support of the LARP production will be implemented based upon requirements which are identified and clarified through actual experience with LARP development in the summer of 1993. The following functionality is considered to be the minimum level of support required to produce LARP Rev. 1.

5.1 TEXTUAL DATA REPOSITORY TO SUPPORT LARP PRODUCTION

A well organized and administered textual data repository will be needed to provide storage and retrieval functions for the LARP materials. This textual data repository should accommodate both word processing and plain text documents, by incorporation of capabilities to meet the following requirements.

- Standardize and Install Word Processing Software on All Workstation Platforms. Wordperfect has been selected as the standard word processing software to be used in the production of all CNWRA final products. Therefore, Wordperfect will be required on all workstations platforms.

- Network-Based Repository for Textual Data. A network-based textual data repository will be required to permit storage and retrieval of textual data from any of the supported workstation hardware/software platforms. This will permit users with appropriate authority to access and update textual LARP work products (RRTs, CDSs, CDMs) from any type of work station, and will make these same work products immediately available to management and other staff members for review and comment.

- Cut/Paste Facilities for All Materials in the Textual Data Repository. Facilities will be required to permit users with appropriate authority to access materials in the textual data repository and cut and paste portions of those materials to form new documents or update existing work products. This capability would specifically support incorporating portions of CDSs/CDMs into individual review plans.

5.2 DISTRIBUTED SYSTEM TO SUPPORT LARP PRODUCTION

As indicated by the preceding analysis of system alternatives, a network-based system with a client/server system architecture provides the best approach for PASS/PADB. This requires several major changes in the system architecture when compared with previous mainframe based implementations of PASS/PADB. Three of these major changes are as follows:

- Open System Design. The NRC, to some extent, and CNWRA presently utilize four distinct PC or workstation hardware/software platforms. The system must support all of these environments and must do so with a user interface that "looks and feels" the same regardless of which platform is being used. This dictates an "open system architecture" where the primary code is independent of the specific hardware/software environment in which it is executed. This

open system architecture coupled with the implementation of Graphical User Interfaces (GUIs) will make the applications look the same on different platforms and will avoid the requirement for retraining of users moving between PC or workstation environments. All applications will share a common "look-and-feel", and the way that users interact with the system will be consistent from application to application. The open system architecture implementation also assures the highest degree vendor independence, expandability, and portability for implementing future applications with a minimum of disruption.

- Distributed Client/Server Architecture. In the last several years the computer industry has concentrated on Client/Server as the architecture of choice for implementing new systems (IDC, 1992). Client/Server is an architecture that combines one or more server computers to provide centralized, special services linked by a local- or wide-area networks with multiple client computers that the users interact with. The server computers can be optimized towards the service that they perform (such as databases or massively parallel computing) while the clients are tailored to the functions that their user performs (e.g. a SUN workstation for a modeler, a Macintosh for a geochemist, etc.). Any server or client computer can be changed or modified without affecting the entire system. The server need only be powerful to perform the functions required to provide the service; it need not be as powerful as if it were performing functions for the entire system (such as in a mainframe system).

  The system should be based upon a client/server architecture in which primary functions such as database management and text storage and retrieval are implemented within a centralized server. Support for the user interface, presentation interface, and data entry are implemented as client functions on the PC or workstation. This approach has several distinct advantages.

  - Server functions (e.g. management of the textual data repository and full-text search facilities) are separated from client functions (e.g. word processing and user interfaces). user response reamins more stable while the system interacts with another user, because all user interface processing is done in parallel on each user's client computer. Therefore, the system scales better to adding more users because new client computing power is added as each new client is added.

  - Components and functionality on one platform may be changed without impact to other platforms. So long as each client or server can respond to the same request/answer message from the other computers, the components can be changed or modified as desired.

  - Disparate hardware/software environments can access a common set of applications.

- Graphical User Interface (GUI). Considerable research in human factors engineering in the past two decades has focused on user interface design for computers (Helander, 1991). Graphical User Interfaces (GUIs), also known as Windowing Systems, implement an interface that more closely relates to the way in which humans work (Card, 1985). For example, windows displaying various data items can be rearranged on the screen in the same fashion as users rearrange the papers on their desks, concentrating on only those that are necessary to perform the current task. The manner in which users interact with the items on the screen is also patterned after real work practices. Termed "direct manipulation" (Schneiderman, 1982), programs or data that the user interacts with are represented by pictures or icons that look like

real world objects (folders for disk directories, dog-eared pages for files, trash cans or shredders for deleting files, terminals for connecting to other computers, etc.) and users move or manipulate the icons to perform actions (dragging a folder to a shredder to delete a subdirectory and its files, "opening" a trash can to recover deleted files, etc.).

PASS Version 2.0 was implemented as a non-GUI, menu-based system. To accommodate the number of options the system offered a "deep" menu hierarchy ("deep" referring to the number of levels between the opening and the lowest level menu). Research has shown that error rates increase from 4.0 percent to 34.0 percent as the depth of a menuing system increases from one to six levels (Snowberry, 1983). This was confirmed by CNWRA user experiences with PASS Version 2.0. A GUI decreases such error rates by grouping related functions in pull-down menus that can be rapidly searched without having to move through a stack of menus. On-line help facilities will be available to assist the user in using the system.

A final reason for implementing the new system using GUIs is the experience NRC and CNWRA users already have in using the GUI currently implemented on their systems. CNWRA IBM PC (Microsoft Windows or IBM OS/2), SUN (Open Look), and Apple Macintosh (System 7) users have already learned how to use their GUI. Implementing the new system in the GUI of their choice will reduce the learning curve and alleviate some of the fears of learning a new application because it will "look and feel" like the programs that they already use.

5.3 FULL-TEXT SEARCH AND RETRIEVAL CAPABILITIES TO SUPPORT LARP PRODUCTION

Experience with earlier versions of PASS/PADB indicated the need for retrieval of records through full-text search. Some of the primary text includes codes of federal regulations, nuclear regulations, SRA records and document references. Some earlier efforts were made to approximate full-text search within PASS/PADB by generating keywords from the text of selected regulations and loading those keywords into relational database tables. A full-text search and retrieval capability provided by utilization of the following software will be needed.

- Full-Text Search and Retrieval Software. From the user's perspective, full-text search is very desirable, particularly in combination with structured search capabilities which are directed toward retrieval of information based upon the contents of the relational database.

- Integration of the Full-Text Search and Retrieval Software With the Textual Data Repository Management Facilities. The full-text search and retrieval software should be integrated with the textual data repository so that authorized users will be able to perform full-text searches and then, subject to document control and user authority procedures, retrieve the selected document(s) for review and/or update.

5.4 DATA CONTROL FACILITIES TO SUPPORT LARP PRODUCTION

All implementations of PASS/PADB have included provisions for data control procedures to assure that the review status, QA status, and other control parameters pertaining to PASS/PADB materials are properly maintained. A Structured Query Language (SQL) compliant relational database has been used for this purpose as well as for storing information about the relationships between various PASS/PADB

records. Implementation of the following four facilities would provide adequate capabilities for data control.

- Check-In/Check-Out Facility for Word Processing Documents in the Textual Data Repository. A textual data Check-In/Check-Out facility will be required to facilitate the work groups and to provide security and control for the textual data repository.

- Integration of Full-Text Indexing With the Check-In/Check-Out Facilities. Document Check-In/Check-Out facilities should be integrated with the full-text search and retrieval modules to assure that all documents are indexed and prepared for full-text searching when they are checked in to the textual data repository. Interfaces should be developed to assure that updated documents are replaced in the full-text indexes and that deleted documents are automatically removed from the full-text indexes.

- SQL Compliant Database Management Software. An SQL compliant database will be required to support the migration of OITS as well as the current and future configuration control and record relationship requirements of PASS/PADB.

- Interface Between Database and Full-Text Search Facilities. Off-the-shelf gateways will be required to permit the SQL compliant database management system to interface with the full-text search and retrieval facilities.

- Interface Between the Database and the Check-In/Check-Out Facilities. An interface will be required between the database and the Check-In/Check-Out facilities to permit authority and usage information to be stored in relational tables and utilized to manage the document creation/modification cycle.

6 SUMMARY

Versions 1.0 and 2.0 of PASS/PADB were implemented as part of the evolution of the concept of PA and its application to analyses and work processes which produced the initial RRs and Regulatory Uncertainties. These implementation efforts performed a valuable role in providing a proof of concept for the PA, defining work processes, establishing program controls, and identifying program needs. As the program evolved, a number of changes occurred in the understanding of the data scope and requirements of the system as well as the work processes and needs of users both at the NRC and the CNWRA. Recent changes in the thinking about the format and content of PASS/PADB have reflected a desire to simplify the organization of SRA data, data relationships, and reporting formats and to focus on near-term regulatory products and goals.

Due to the constraints imposed by the IBM 4381 mainframe computer technology and the speed of the 9.6 kB leased line, earlier implementations of PASS/PADB were not sufficiently responsive, user-friendly, or cost effective to meet the long-term needs of the repository program. However, the following considerations discussed herein combine to indicate that the application of newer technologies and system approaches along with increasingly clear definition of user needs will permit PASS/PADB to make a significant contribution to the production of the LARP in FY93 and succeeding years. These considerations are:

- Emerging system requirements;
- Changes in NRC and CNWRA computing environments;
- More capable and cost-effective technology available through workstation-based distributed, network-based system environments;
- A favorable economic LCC analysis for the recommended approach.

As a result of the systems analysis presented here it is recommended that PASS/PADB be migrated off of the IBM 4381 mainframe with appropriate system changes, including the planned upgrade of the leased line to 56 kB, to support the new focus and work processes being applied to the production of SRA products. It is further recommended that the PADB be hosted on a client/server implementation of a network-based system compatible with current and planned computer support systems at the NRC and CNWRA.

It is believed that as the functional requirements which have been identified for PASS/PADB are met, a system will be established and refined which will provide significant support for the production of the LARP, both in FY93 and in succeeding years.

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