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Improvement of Operations and Management Techniques Research Program

Corps of Engineers Operations and Maintenance Budget Decision Support System (COMB_DSS): System Concept, Design, and Prototype Evaluation

Volume I: Main Text and Appendix A

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Prepared for Headquarters, U.S. Army Corps of Engineers

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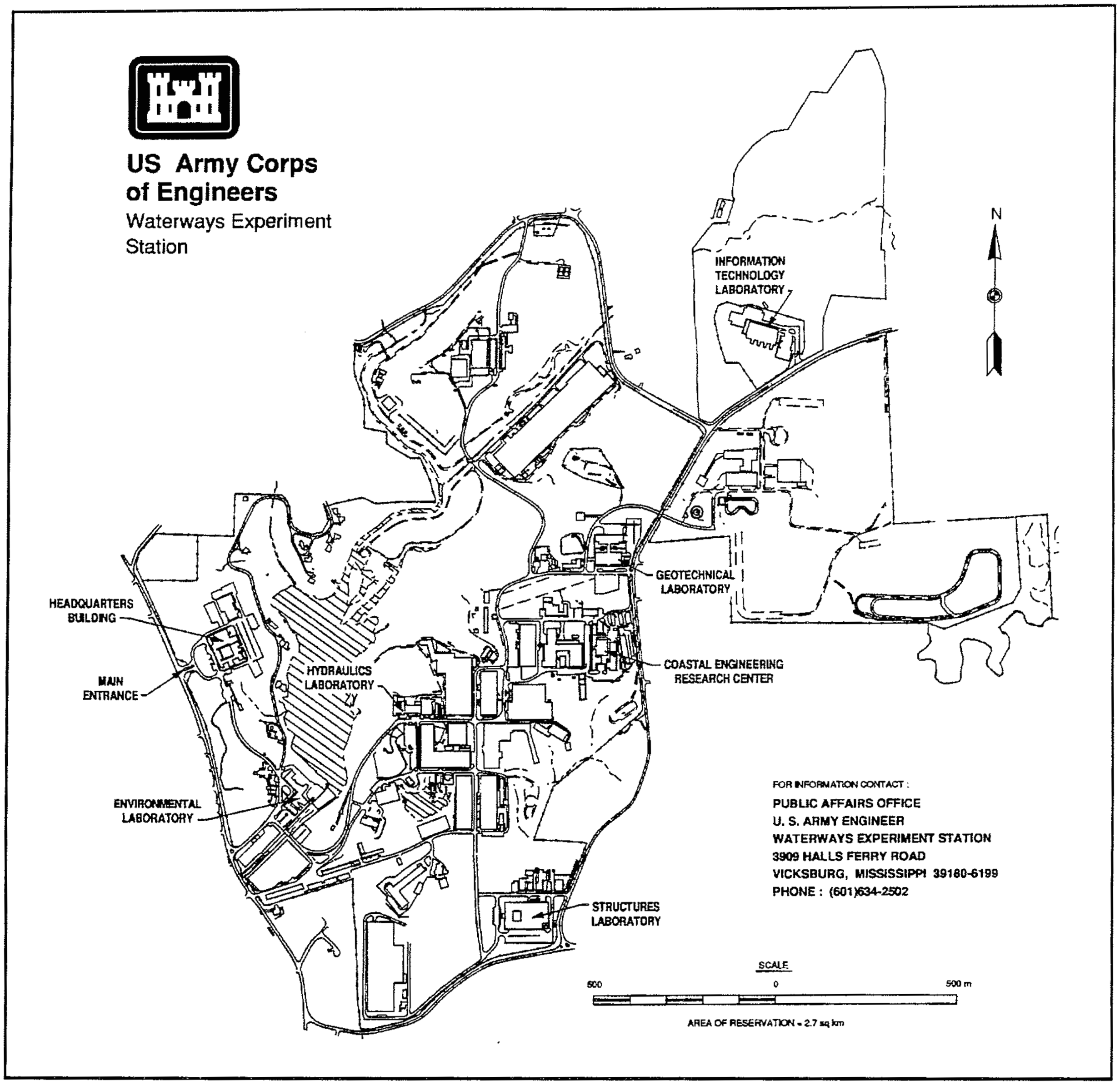

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[1] A limited number of copies of Appendices B through F were published under a separate cover. Copies are available from National Technical Information Service, Springfield, VA 22161

Preface

Decision Support Systems (DSS's) are combinations of computer hardware and software designed to assist decision makers in making complex decisions. DSS's extend the capabilities of management information systems (MIS's) primarily by providing additional analytical capability for examining the impacts of alternative decisions. This report documents an initial research effort under the Improvement of Operations and Management Techniques (IOMT) Research Program sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE) General Investigation Program under Work Unit 32717, "The Application of Decision Support Systems to O&M Budget Management," to explore the potential of DSS to assist decision makers within the Operations, Construction and Readiness (OCR) Division. The Corps of Engineers Operations and Management Budget Decision Support System (COMB_DSS) is a working DSS, tested during the fiscal year (FY) 1994 budget cycle, that demonstrates the potential for DSS within the OCR Division. The research team plans to continue to explore the potential of DSS.

This project research was a team effort. IOMT researchers and the users of the DSS combined to conceive, design, implement and evaluate the COMB_DSS. The pivotal member of the team was Mr. Dave Harmon, HQUSACE. Mr. Harmon was the primary user of the prototype COMB_DSS and spent many hours helping the research team develop and improve the system. The success of this effort would have been impossible without his help. Planning and Management Consultants, Limited (PMCL), provided technical support under contract to the U.S Army Engineer Institute for Water Resources (IWR). Mr. Craig A. Strus was PMCL's project manager. Mr. Richard M. Males, RMM Technical Services, Inc., a subcontractor to PMCL, was instrumental in the design effort and was primarily responsible for building the working prototype. Mr. Michael R. Walsh, Technical Analysis and Research Division, IWR, managed the PMCL contract and worked directly with Mr. Harmon during the FY 94 budget process to refine the COMB_DSS. Mr. Stephen H. Scott, Estuarine Engineering Branch, Estuaries Division, Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station (WES), participated in the review process for each version of the COMB_DSS and is the co-principal investigator with Mr. Walsh for the IOMT work unit on DSS that supported the development of the COMB_DSS. Ms. Connie L. Raaymakers and Mr. Edward J. Japel, U.S. Army Construction Engineering Research Laboratory, provided insight into the existing Automated Budget System (ABS), and Ms. Raaymakers provided much of the technical evaluation

of the COMB_DSS during the FY 94 budget process. Ms. M. Cathy Ballard, Information Technology Laboratory, WES, is working on the port of the ABS database to the ORACLE database management system and provided helpful information for the design of the database component of the COMB_DSS. This report was written by Messrs. Strus, Russ E. Robinson, PMCL, Males, Walsh, Japel, and Ms. Raaymakers.

Messrs. Jim Crews and Mr. Robert Daniel, HQUSACE, were Technical Monitors; and Mr. Robert F. Athow, Estuaries Division, was the IOMT Program Manager. The contract was monitored by Messrs. Walsh and Scott. Contracting Officer was COL Leonard G. Hassell, EN. At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Summary

This report describes the development and use of a personal computer-based decision support system to assist with operations and maintenance (O&M) budget analysis. The Corps of Engineers Operations and Maintenance Budget Decision Support System (COMB_DSS) is the first product of the work unit entitled, "Decision Support Systems for Operations and Maintenance," under the Improvement of Operations and Management Techniques (IOMT) research program. The objectives of the COMB_DSS effort were to assist the Operations, Construction and Readiness (OCR) Division, Headquarters, U.S. Army Corps of Engineers (HQUSACE), with analysis and decision making about yearly budget submittals by Corps Divisions and to demonstrate the potential of decision support systems for assisting the OCR Division with crucial decision making. The project was successful on both counts.

Much of the success of the effort can be attributed to the approach used to develop the COMB_DSS. The project was highly focused on a well-defined, relevant problem. The Automated Budget System (ABS) offered a database framework on which the decision support system could be built. The project team included personnel from the U.S. Army Engineer Institute for Water Resources, U.S. Army Construction Engineering Research Laboratory, and U.S. Army Engineer Waterways Experiment Station who were familiar with the existing ABS system as well as the principles for sound decision support system development. The team worked directly with the primary user of the system to ensure that the system performed crucial tasks effectively. The COMB_DSS was developed using an iterative, rapid prototyping approach. Rather than spend considerable time and effort in developing detailed requirements and design specifications before coding and testing, a version of the COMB_DSS was built early in the development process, based on preliminary requirements and design specifications. This allowed the user hands-on experience with the system very early in the development cycle, thereby providing the development team with rapid feedback on what worked and what did not work. Thus, the design team was able to respond quickly with improved capabilities.

The COMB_DSS works with the existing ABS budget data that are transmitted to HQUSACE each year from Districts and Divisions. ABS data contain information about approximately 20,000 work functions that are candidates for funding in the budget process. These work functions have been prioritized by Districts and Divisions, are analyzed by the OCR Division in terms of national

1 Introduction

Background

This research effort to develop the Corps of Engineers Operation and Management Budget Decision Support System (COMB_DSS) is part of the Improvement of Operations and Management Techniques (IOMT) research program. The objective of the IOMT program is to (a) reduce costs while increasing the safety and efficiency of operations and maintenance (O&M) management, (b) enhance the utility of O&M assets such as locks, dams, and vessels, and (c) address the economic and budgetary issues in the O&M function.

Initially, the work unit on the application of decision support systems (DSS's) within the Operations, Construction and Readiness (OCR) Division, Headquarters, U.S. Army Corps of Engineers (HQUSACE), was designed to explore opportunities for DSS, select high-priority opportunities, and develop a prototype to test the effectiveness of DSS. When the objectives of the work unit were explained to the Field Review Group at the first review meeting of the IOMT, the Field Review Group saw an opportunity to enhance the existing O&M budget process by developing a DSS that would improve the analysis of budget submissions for each fiscal year (FY) budget. The Field Review Group suggested that the research focus on developing a DSS to assist with decisions about the budget process. The development of a working DSS would demonstrate the usefulness of DSS and provide immediate benefits by improving the budget decision process. Thus, the research changed direction to develop a DSS to assist with the budget decision process. The starting point for the research was the Automated Budget System (ABS).

The Budget Process

The OCR Division has instituted a fully developed budget process under which O&M programs are funded. This process requires the identification and prioritization of about 20,000 work functions. Each year a set of the highest priority work functions are selected for funding comprising a total budget of about 1.5 billion dollars. The projects must be identified, budgeted, and prioritized at the District and Division levels, and they are subsequently combined by HQUSACE into a single data set for further analysis, work function ranking, and selection. The final ranked list of work functions, as developed by HQUSACE, is incorporated into the final budget proposal for O&M appropriations.

To facilitate the smooth transition of information from the Districts through Divisions to HQUSACE, the ABS, a management information system, was developed by the U.S. Army Construction Engineering Research Laboratory (CERL). The ABS enables computerized collection, editing, and transfer of work functions up the hierarchy. The entire submission of all work functions is stored on a mainframe computer and accessed using a network database management system (DBMS). This DBMS allows for the production of standard reports and ad hoc queries of the work function data.

Once information has been passed from the Districts, through the Divisions, to the mainframe ABS database, the work functions must be analyzed to decide which ones will be included in the current year budget submittal and which ones will fail to make the cut. Within the budget process, HQUSACE relies primarily on the Division ranks to determine the priority of work functions. However, there are national priorities that sometimes override the Division rank. The reranking process required tedious manipulation of the HQUSACE rank for each work function. There has been no easy way to provide an audit trail of changes to work function ranks. Additionally, under the budget process, all data analysis at HQUSACE was accomplished on a mainframe computer. This limited the flexibility of the analysis and resulted in high computing costs. The process of selecting work functions for funding required tedious manipulation of work function ranks. A representation of the original O&M budget process is shown in Figure 1. A better, more effective process was needed. The ABS system and its interaction with the O&M budget process is described in detail in Appendix A.

Still, the existing budget system was an excellent starting point for the development of a budget DSS. First, the database structure is stable, contains the information needed for the budget decision process, and is extensible in that additional information, such as condition indices, can be added to the database. Second, the ABS is accepted throughout the OCR Division as the vehicle for budget submissions. Third, there is a high degree of institutional knowledge about the budget process from the District level through the HQUSACE level. Finally, IOMT is investigating developing additional data elements for each work function, such as condition indicators and benefit/cost indicators, that will require analysis in future budget cycles. The analysis process must consider these new data elements.

Research Overview

The objectives of this study were to develop a system concept and build a functional prototype DSS that HQUSACE-level decision makers could use to help make decisions about the O&M budget.

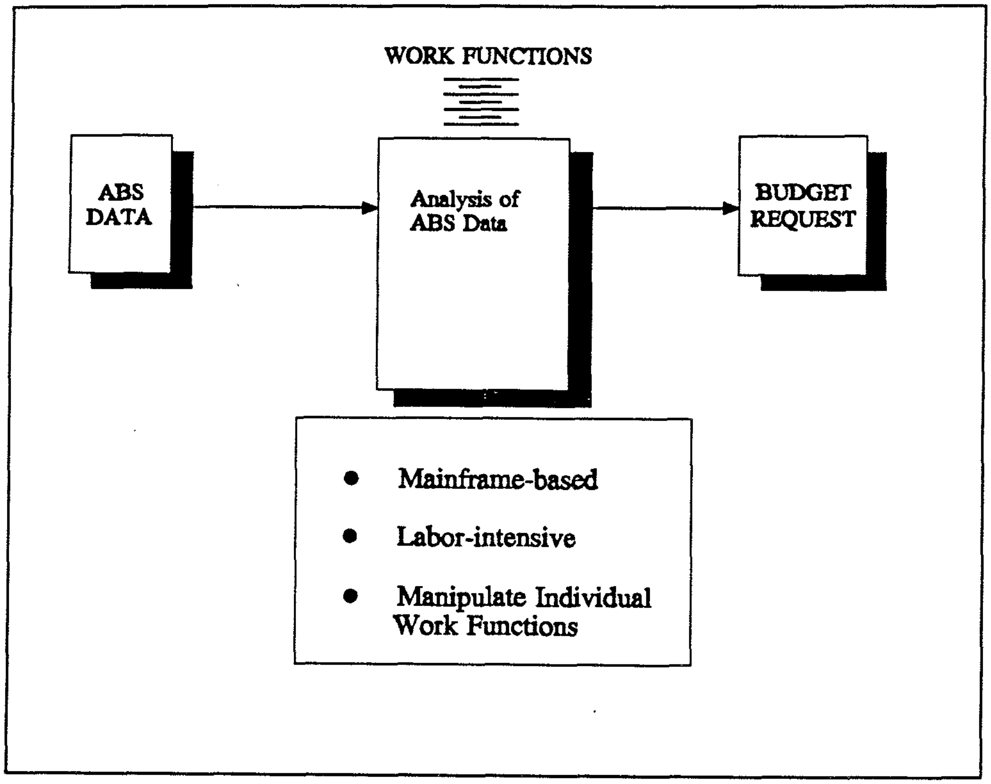

Figure 1. Representation of the original O&M budget process

The COMB_DSS was initially designed to provide HQUSACE with five major analysis modules, as follows:

a. Scenario Analyst.

b. Financial Analyst.

c. Ranking Generators and Evaluators.

d. Criteria Analyst.

e. Statistical Analyst.

In the prototype system, only the first three modules were implemented. During the design phase, the development team sought to restructure the problem paradigm (i.e., change the way the problem solver approaches the solution to his/her problem). A key to this change was the concept of the "scenario," simply a group of work functions, defined in some fashion, with no implied ranking. By providing simple methods for defining scenarios, and combining scenarios into new scenarios, a "set-oriented" approach, in which groups of work functions are manipulated, rather than individual work functions, becomes the guiding principle for the analysis. Some of these "shifts" in thinking included (a) storing scenarios versus performing ad hoc queries and printing reports, (b) reorganizing the approach such that changing work function ranking is done at the end of the process, rather than continually, as with the mainframe system, and (c) developing the capability to store derived scenarios as a composite, based on Boolean combinations, of existing scenarios.

The COMB_DSS was used in the budget process as a replacement for the mainframe-based management, analysis, and reporting of work function data. Once all work functions were uploaded to the mainframe from the ABS, the appropriate data were downloaded into the COMB_DSS, where data checking, scenario development, financial analysis, and rank generation were carried out during intensive system use in June, July, and August of 1992. The system was used to provide a variety of reports to upper management, with extreme interactions in terms of scenario definition. Once final rankings were developed, the information was uploaded to the mainframe, to be available to Districts and Divisions through the ABS process. The use of the COMB_DSS in the budget process is shown in Figure 2.

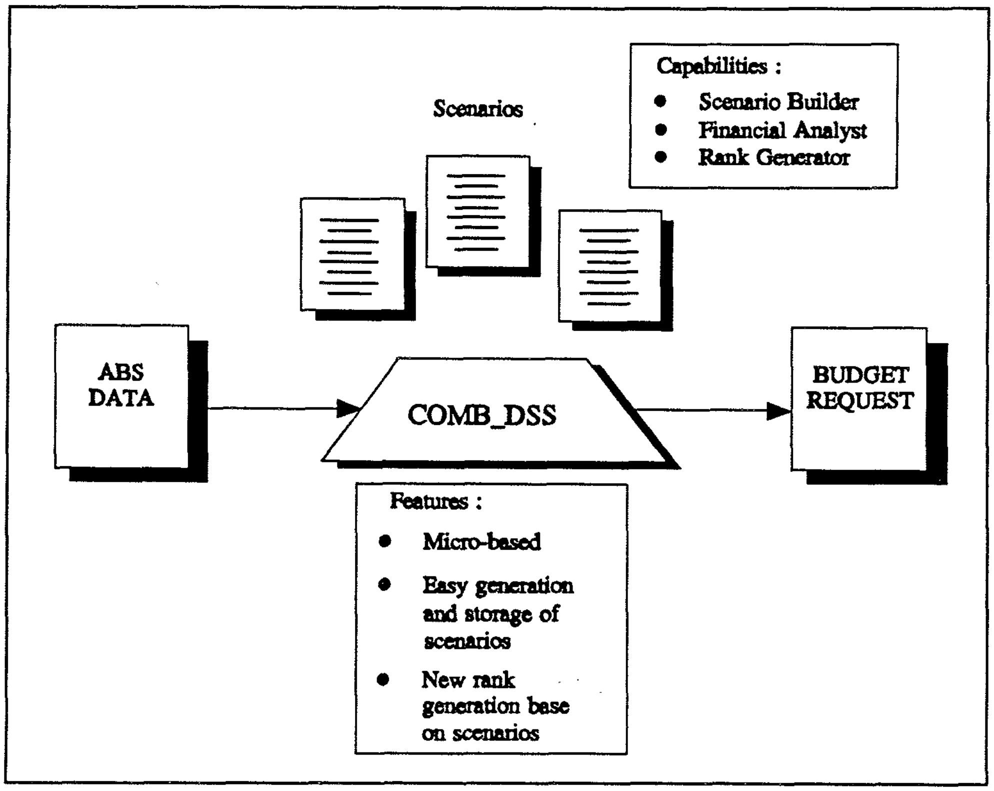

Figure 2. Representation of the O&M budget process with the COMB_DSS

While the COMB_DSS was being used in the budget year 1994 budget submittal, an internal evaluation process was carried out in which members of the project team examined how the COMB_DSS was being used and its strengths and weaknesses.

Overview of Report

This chapter contains a background and overview of the work effort, including project sponsors and study objectives. Chapter 2 discusses, in generic terms, the DSS framework and system components, the development approach, and the steps typical of developing a DSS. Chapter 3 provides detail on the development of the COMB_DSS prototype(s) in terms of concept, design, and functional components. Chapter 4 contains an evaluation of the prototype as used by HQUSACE. Chapter 5 discusses future plans for improving the COMB_DSS prototype, developing COMB_DSS capabilities for Divisions and Districts, and exploring other potential DSS applications for the OCR Division. Chapter 6 contains project results and conclusions. Appendix A contains a detailed description of the existing ABS. There are five additional appendixes that are available separately. Appendix B is the Micro-ABS/Mainframe ABS data dictionary. Appendix C contains technical memos and the minutes to project team meetings. Appendix D provides documentation on the COMB_DSS tables and structures. Appendix E provides sample COMB_DSS menus and forms. Appendix F contains COMB_DSS sample reports. Appendix G contains presentation materials used at the Operations Chiefs and IOMT Field Review Group meetings held in March and April of 1992 in Las Vegas, NV, and Portland, OR, respectively.

2 DSS Framework and Development

DSS Components

Decision Support Systems are computer-based information systems that support semi-structured or unstructured decisions. Due to the complexity of these decisions, using proper models can significantly improve human performance by (a) facilitating understanding about the decision problem, (b) examining more alternatives, and (c) enhancing prediction capabilities. Thus, a model management system that supports the development of decision models and their subsequent use is considered crucial to the success of a DSS.

Early research in model management considered models as data or subroutines and proposed that a model management must support model creation, storage, retrieval, execution, and maintenance. Latter research has focused on two issues: model base organization and model representation. However, a well-developed DSS must have the additional capability of selecting and integrating existing decision models (analysis components). Thus, models stored in the analysis component of a DSS should serve as (a) stand-alone decision models, and (b) building blocks from which more complex decision models can be built. When a DSS contains these two additional capabilities, it can better support decision makers by formulating ad hoc models to meet unanticipated requirements quickly.

Typical DSS's contain four major components, as shown in Figure 3. The database component is designed to facilitate storage and retrieval of model selection criteria and model results. The database design should consider (a) selection criteria required of the analysis component, (b) the speed with which required data can be retrieved, and (c) how output database tables should be created to properly represent, integrate, and report information resulting from analysis.

The user-interface design should be intuitive in terms of menu structure and forms access. The menus should allow the user to follow a logical progression of information management, model selection, analysis, and results processing. Forms design should focus on providing the user with a window to the

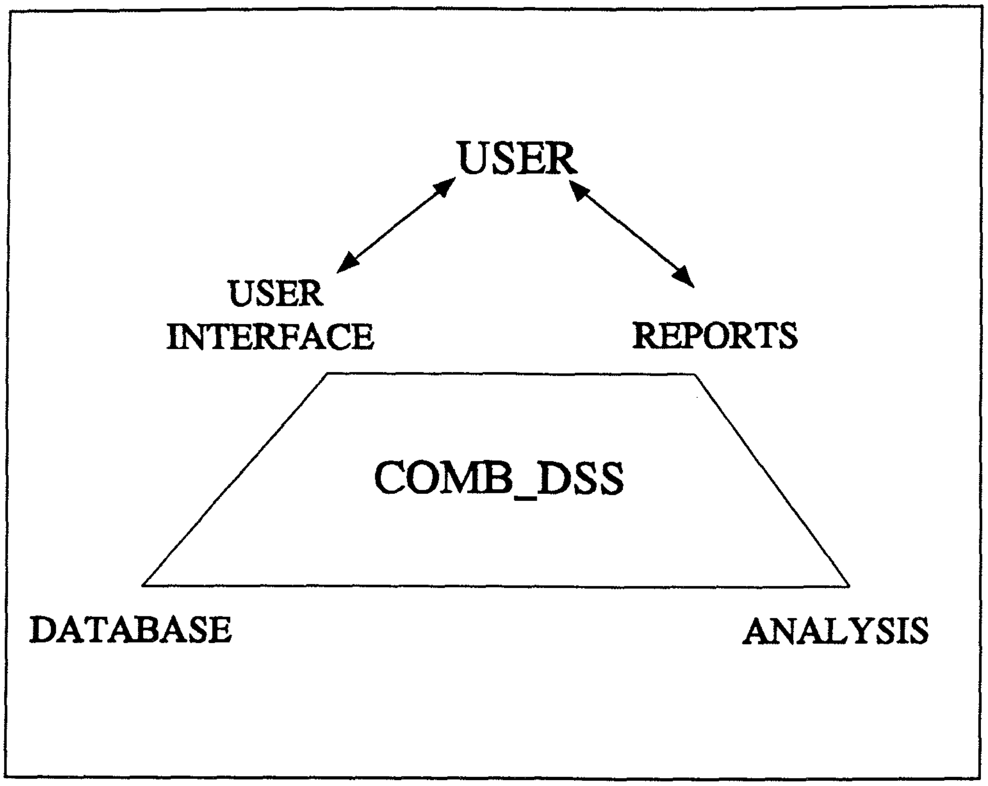

Figure 3. Representation of a DSS

database. The layout of forms or "database windows" should consider data most commonly required by the DSS analysis models.

The analysis tools should maintain a building block capability, as described previously, and should focus on the types of decisions that will be made from DSS analysis. Furthermore, the analysis tools must also be flexible in nature, thereby allowing ad hoc queries reaching the bounds of the model domain to be properly answered. Finally, the analysis tools must be extensible and comprehensive so that they can be easily adapted to a potentially changing problem domain.

Development Approach

A typical development approach consists of (a) identifying a well-defined problem domain for which a DSS can be developed, (b) identifying a development team with the technical expertise required to address inevitable DSS hardware/software issues, as well as a background in modeling approaches that will provide solutions to the problem domain, and (c) finding Technical Monitors (Clients) who are subject matter experts and who constantly require solutions, under varying domain specifications, within the problem domain.

DSS Development Methodology

DSS development typically follows a logical and generic progression of events. There are typically four components:

a. System concept. The system concept specifies the requirements for the DSS, describing how the DSS will assist in meeting the requirements, and serves as a way to communicate the "vision" of the DSS to decision makers. The system concept report should address the following topics: User Requirements; Feasibility Constraint Assessment; Development of a Functional Model; Selection of Methods; Assessment of Appropriate Software and Hardware; Development of Methodologies for System Packaging, Transfer, Documentation, Maintenance, Support, and Evaluation.

b. System design. The system design is a "blueprint" for the DSS, specifying the hardware and software to be used and outlining the steps to be taken to build the system. The system design report documents the system specifications, contains system documentation, and provides a testing and evaluation plan.

c. Implementation. Although DSS implementation can be managed with a variety of methods, a cyclic approach is desired, in which the design team develops "real" prototypes, evaluates them, and returns to concept for another iteration. This approach is superior to most others because (1) proof-of-concept is verified, (2) an evolved prototype exists when the project is complete, (3) the review and testing feedback loop is complete, and (4) functional risk is minimized in the evaluation phase. Implementation should include a modular or "building block" approach to functional components. In this fashion, functional components can be developed and tested quickly and concurrently by different team members. Rapid prototyping will quickly determine the success or failure of a DSS project.

d. Evaluation. Under the iterative prototype development approach, system evaluation and resulting improvements are accomplished in a step-wise fashion. Thus, upon project closure, the design team and clients are usually aligned and agree with the functional aspects of the final DSS product. That is, functional risk is minimized or resolved in the course of prototype development.

The process is not linear, but rather "looping." Between concept and design may come iterative prototyping, which typically requires the design team to return, to some degree, to concept. By allowing users to interact with a series of "real" but limited versions of the system, this approach minimizes the risk associated with having the final system fall short of expectations. During implementation and evaluation, additional features may be desired, or new techniques and approaches may evolve, which serve to change the concept and design specifications.

This iterative, rapid prototyping approach was followed in development of the COMB_DSS, and proved to be very valuable. In particular, the rapid prototyping approach provided a strong framework for development and critiques, as there is always something "real" to work with and evaluate.

3 COMB_DSS Prototype Development

Concept

Following the general outline of DSS development practices, with emphasis on prototype development, COMB_DSS efforts began with a requirements analysis, in which the project team examined (a) the existing ABS database, (b) the current ABS budget cycle and information flow, and (c) the types of analyses performed by HQUSACE. The design team found the ABS, written and maintained by CERL, to be a workable and concise management information system. Thus, it was concluded that the development of iterative prototypes, in which modeling, database, and user-interface components would evolve with each iteration, was the most logical way to proceed.

The ABS system was examined to determine its role in the O&M budget process, and a detailed description can be found in Appendix A. The ABS results in a set of work functions, defined and ranked by Districts and Divisions, residing on a mainframe computer. These work functions are then analyzed and ranked by HQUSACE to provide a complete ordering of all work functions. This allows for a clear determination of the work functions that will be funded as the actual budget is finally set. The ranking process, carried out prior to this year on a mainframe, is costly, cumbersome, and labor-intensive. Based on the nature of the problem, HQUSACE's desire to improve the process of handling ABS data, the decision support activities were directed to this end (i.e., postprocessing of the ABS data for purposes of ranking and evaluation).

The analyst in the OCR Division responsible for technically supporting the annual work function rankings served as the key "client representative," providing information as to the nature of the problem, ongoing evaluation, and testing and use of the prototype(s). Additional review and guidance were provided by other members of the project team. The particular approach selected for system development was that of iterative prototype development and refinement. In this method, a series of prototype systems are generated and reviewed by the client. Each system provides increasing capabilities, as guided by the reactions and results of the previous prototype. The approach demands a good deal of interaction between the developers and the client, and rapid response of both parties. The actual project generated some six prototype versions. Changes to the prototypes were extensively documented in internal technical memos.

After an examination of the existing ABS cycle and software, budget guidance circulars, and the information requirements of HQUSACE, the design team evolved a structure for the COMB_DSS based on the organizing concept of "scenarios." A scenario is simply a set of criteria that serve to select a subset of work functions from all available work functions. An example scenario would be "all navigation work functions in ORD." This criterion can be applied to the information stored about each work function (from the ABS) to determine which work functions meet the scenario criterion, and thus are in the scenario. Each scenario thus implies a set of work functions, an associated cost for the scenario, and a distribution of that cost by District, Division, project, etc.

The scenario concept allows for redesigning the approach to work function ranking away from individual work functions and toward thinking of work function groups. Under the scenario concept, assigning ranks to work functions is the last step in the process. Prior to that time, work functions are grouped into scenarios and the financial implications of individual scenarios and combinations of scenarios are compared. When ranking under the scenario concept, whole scenarios are given preferential ranks. In effect, when work functions are "moved up or down," they are moved up or down in groups. A two-step ranking process involves first ranking the scenarios, then generating ranks at the work function level based on defined algorithms. The consequences of ranking can then be evaluated in financial terms and in terms of disrupting the rank order preference of work functions within a Division.

The scenario approach is in contrast to the prior method, in which all work functions are reranked whenever it is necessary to develop a new set of financial reports based on different criteria. Drawbacks of the prior method include (a) a high degree of labor intensiveness, (b) difficulty in maintaining a paper trail or history to show what had been done previously, (c) high mainframe computer costs, and (d) lack of flexibility.

The COMB_DSS was structured with five modeling components, in order of priority desired for implementation, as follows:

a. *Scenario analyst.* Given a ranking range and additional selection criteria (e.g., appropriation code), determine whether a particular work function is in or out of a scenario.

b. *Financial analyst.* How does a given scenario and dollar amount result in distributing dollars to Districts and Divisions among categories, classes, feature cost codes, etc.? How do scenarios compare in terms of these distributions of costs?

c. *Rank generator.* Given a set of scenarios, generate a rank for each work function and evaluate the resultant ranking.

d. *Criteria analyst.* Given criteria that describe a function, descriptive reports are generated. (It is assumed that additional criteria will become available in the future, as more research is conducted, e.g., condition index.)

e. *Statistical analyst.* Perform "discovery" to look for relationships in the database, generate overall statistical measures from the database.

The scenario analyst was identified by HQUSACE as the most urgently needed capability, and this was addressed first in the prototype development. The final COMB_DSS version includes the scenario analyst, rank generator, and financial analyst modules. The criteria analyst was not developed because additional criteria, such as condition index and benefit-cost ratios, were evaluated in the scenarios. When additional criteria are added to the ABS database, the criteria analyst will be added to the COMB_DSS. The statistical analyst was not considered necessary during the prototype testing.

Design

The COMB_DSS was implemented for a personal computer-based 386 or better computer system, using the DOS operating system and the R:BASE relational database management system (RDBMS). Versions 3.1b through 4.0 of R:BASE were used as they were released by the vendor. Although ORACLE Version 6.0 was evaluated, R:BASE was used because of capabilities that allow rapid prototyping. The use of R:BASE will readily facilitate system transfer to ORACLE under DOS or another platform with operating environments that support SQL.

As noted previously, the scenario concept was at the heart of the new approach to analysis and ranking. In keeping with the relational database structure underlying the DSS, the definition of a scenario is stored in database tables, and the results of scenario evaluation are likewise stored in tables.

The key table of the COMB_DSS is the WORKFUNC table, containing information on each of the individual work functions, including District, Division, CWIS number, District and Division rank, initial HQUSACE rank, descriptions, project class, and feature cost code. This table is downloaded, essentially as is, from the mainframe ABS, and reflects the input of Districts and Divisions and the initial ranking, as developed by HQUSACE, based on the Division ranks. Information stored in this table is not changed, through the entire process, until the final assignment of revised ranks.

Three methods of defining scenarios were developed:

a. *Primary scenarios.* Defined as a set of criteria that operate as a selection mechanism for work functions stored in the WORKFUNC table, and entered through a forms-oriented interface.

b. Composite scenarios. Boolean combinations of existing scenarios, i.e., the union of all of the work functions in a set of scenarios, or the intersection of the work functions in two scenarios (those work functions that are common to both scenarios.)

c. SQL scenarios. Scenarios defined by applying a user-defined query using SQL to the WORKFUNC table.

The general approach to scenario development is as follows:

a. Create a scenario through one of these three methods.

b. Generate the set of all work functions that fit the scenario criteria as a temporary table [the TEMPSCEN table] containing only those work functions that are in the scenario.

c. Evaluate the temporary table, from a financial point of view, in terms of the cost breakout by District and Division, Project Class, and Feature Cost Code.

d. Store, if desired, the set of work functions in the scenario as a "permanent" scenario for later recall and for use in building composite scenarios. When a scenario is stored, the financial summary data for the scenario, by Division, Class, and Feature Cost Code are also stored in tables, so that comparisons can be made without recalculating financial statistics.

As noted previously, the scenario approach is new. Initially, the COMB_DSS was designed to handle a maximum of 64 scenarios, based on user input. During the course of the effort, this number was expanded, first to 128 scenarios and finally to 256 scenarios as more and more use was made of the composite scenarios.

As increasing use was made of this approach, the need to rapidly generate, evaluate, and store multiple scenarios increased. Accordingly, as the prototypes evolved, more efficient methods for handling the scenario generation were developed, but the basic concept of this flow was maintained.

Scenario analyst

The COMB_DSS contains a "Manage Scenarios" capability, in which primary, SQL, and composite scenarios can be entered, edited, copied, deleted, and renamed. The primary scenario selection criteria include appropriation code; a range of HQUSACE ranks; a range of output measures (to become condition indices); two user-added ranges that are not currently used; minimum cost; cumulative cost; inclusive divisions; inclusive classes; and, include/exclude capabilities for CWIS numbers, HQUSACE ranks, and feature cost codes. A forms-oriented interface allows for easy specification of these criteria.

A composite scenario is, as noted previously, an integration of primary scenarios, built through an intersect, union, or subtraction process. A *U* (union) scenario will provide the union of work functions specified (i.e., any work function in any *U* scenario is in the composite). An *I* (intersect) scenario gives the intersection of the *I* work functions (i.e., the work function must be present in all *I* work functions to be included in the composite). The *S* scenario subtracts work functions in the *S* scenarios from the work functions in the *I* scenarios. The *S* scenario cannot be combined with the *U* scenarios, only with the *I* scenarios, and *I* and *U* are also mutually exclusive. When *S* and *I* are processed jointly, the *I* scenarios are processed first, and then the *S* scenarios are subtracted.

The COMB_DSS also contains a feature that allows the user to build an ad hoc SQL scenario. This allows consideration of selection criteria that are not in the current primary selection criteria forms. In actual use, this feature was not utilized extensively.

Financial analyst

Financial analysis takes place at three different levels: by comparison of scenarios Corps-wide; by detail within a Division; and by work function within a scenario. The first two levels allow for comparison of up to seven scenarios, in terms of dollar cost breakouts by Division, by Feature Cost Code (at prefix or detail level), and by Project Class. This allows for rapid comparison of the "distributional" impacts of various scenarios. Detailed reports for a given scenario display information for each of the work functions in the scenario. The format of these reports was designed, based on client preferences, to be as close as possible to the prior, mainframe-generated reports, in order to present results to decision makers in a familiar format. It should be noted that, although graphical display capabilities are generally thought to be an integral part of a DSS, in the current case, client orientation was much more strongly toward familiar numerical reports. The use of the roll-up tables that stored financial summaries for each scenario made generation of the required reports much faster. An additional type of financial analysis is also provided, post-ranking, to evaluate the consequences of ranking scenarios.

Rank generator

The prior ranking method involved continual assignment of HQUSACE ranks at the work function level. Under the COMB_DSS approach, ranking is approached at the scenario level. The user assigns "scores" to each scenario, reflecting the desirability of the scenario, in terms of funding, with a lower score representing a more desirable situation. Once scores are assigned at the scenario level, a process exists to assign scores at the work function level. Given the nature of scenarios, a work function can be in many scenarios. A variety of algorithms were explored to determine how to assign a work function score based on scenario scores, including weighting scenario scores, summing scenario scores, or using the best score. The "best score" algorithm simply looks at all of the scenario scores for all scenarios in which the work function is present, and assigns to the work function the best (in this case the lowest) of these scores.

The process results in assignment of a score to each work function, but these scores are not necessarily unique. The ultimate desire is a unique ranking number for each work function, correlating to a funding level. Again, a number of different algorithms were explored to assign unique ranks. The overall desire is to rank all work functions that share the same score, in order. The eventually adopted method, based on user preference, was to use the original HQUSACE rank (based on Division and District assigned ranks) to order work functions within a score level, leading to a unique rank.

Financial analysis components allow for determination of total costs based on scenario scores, so that the dollar consequences of assigning any set of scores can be reviewed.

The rank generation process provides a good deal of flexibility, and allows for a number of options in developing ranks. Given the time constraints for development of the recommended budget submittal, the rank generation capabilities of the COMB_DSS were not fully explored, as primary emphasis was devoted to scenario generation and evaluation.

Implementation

The COMB_DSS final prototype was developed in R:BASE 4.0, using DOS version 5.0 as the primary operating system, and installed at HQUSACE on a Compaq 486/50L microcomputer. The Compaq is a server machine on a Novell 3.11 Local Area Network and maintains connectivity with workstations through IBM token-rings and twisted-pair coaxial connections.

Six prototypes were developed. The first prototype approach was far off the mark, and was abandoned. The next five prototypes were evolutionary developments, with changes oriented primarily toward speed, ease of use, and additional features, but with the basic framework remaining intact. A major improvement, in moving from prototype 2 to prototype 3, involved development of an external processing procedure for storing the status of a work function in a scenario. The initial, relational implementation proved too slow and cumbersome.

A work function's status in a given scenario can be stored in a single bit, as a 1 (work function is present in scenario) or 0 (work function not in scenario). This suggested the use of bit fields as a compact method of data storage for this information. Conceptually, a table could be created, with a row for each work function and columns representing the 1/0 flag, for as many columns as the maximum expected number of scenarios. This approach was implemented through the use of a set of custom-written C programs that manipulate this table (referred to within the COMB_DSS as the BitMap file). This provided a dramatic improvement in processing capabilities.

Other features developed during the course of iterative prototyping include the financial analyst; rank generators (sets of C programs executed external to R:BASE); additional reporting capabilities; logical checks; initial reports that apply to annual imports from the ABS; and enhanced ease-of-use features such as more descriptive keystroke/screen information, pick-lists, generation of multiple scenarios, and system utilities.

4 Evaluation of Prototype

Technical Performance

The COMB_DSS prototype was applied and tested at HQUSACE over a 5-week period commencing 27 July 1992. It was installed on a Compaq 486/50L microcomputer running Novell 3.11 as the primary local area network. Access to internet and the Civil Works mainframe information base, located on the Washington Computer Center (WCC), was accomplished using the Transmission Control Protocol/Internet Protocol (TCP/IP) inherent in File Transfer Protocol (FTP) version 2.0.5. The Civil Works information database, residing on the WCC mainframe, is accessed, maintained, and extracted using the RAMIS fourth-generation RDBMS.

The COMB_DSS prototype was developed using R:BASE version 4.0, a product of Microrim, Inc., and various C programs written by the development team. The projected size of the extracted database on the WCC mainframe is approximately 22 MB. This extract file was transferred from the WCC mainframe to the Compaq 486/50L in 1.5 hours using FTP running TCP/IP on the Internet. In contrast, it would have taken 8 hours using a 9600 V.32 modem to transfer the same extract file.

The COMB_DSS did accomplish the stated goal of supporting HQUSACE during the O&M budget submittal by (a) increasing the number of scenarios generated in the limited reaction time, and (b) providing a cost-effective alternative to ad hoc query and reporting procedures typically performed on the mainframe system using RAMIS. The COMB_DSS concept fit very well in the HQUSACE Civil Works environment and provided more information for decision making than had been available in previous years. The primary user of the COMB_DSS system stated that the system is significantly better and more cost-effective than what had been used in previous years. The capability of returning to stored scenarios and rerunning them if necessary was a great improvement over previous capabilities.

Overall, the operation of the COMB_DSS system was reasonably intuitive. There was some discussion on the use of function keys and the consistency with which they are used in different areas of the system. The primary concern was understanding the process of scenario building and how composite scenarios were derived from other scenarios. The end-user must be cautioned that scenarios dependent on other scenarios must be rebuilt when those dependencies change. The speed of the COMB_DSS was sufficient to provide the results of the scenarios to high-level decision makers in a timely manner. In addition the capability to evaluate and store multiple scenarios greatly improved productivity and ease of use, when compared to the "old" way of doing things.

The cost savings achieved using the COMB_DSS is difficult to evaluate. Last year's WCC mainframe costs, incurred during scenario processing, are estimated at $11,116.58. It should be noted, however, that the prototype test was more scenario intensive this year than in previous years. If all scenarios built on the COMB_DSS had been built on the WCC mainframe, it is estimated that the cost would have been at least three times the cost incurred in previous years. Thus, the COMB_DSS system appears to be a cost-effective solution.

The COMB_DSS system was designed to be modular such that needed system capabilities that were unforeseen or overlooked could be readily implemented. An upgrade from R:BASE 3.1(c) to R:BASE 4.0 required no system changes. Requests from upper level managers for changes in report formats were quickly addressed by developers of the COMB_DSS in a very short time period. The COMB_DSS accommodates the existing way of doing things at HQUSACE and affords the opportunity to change the process for improved productivity and cost effectiveness.

Although the COMB_DSS system accomplished its objective, problems were encountered during implementation. The most prevalent concern is the reliability of R:BASE; for the COMB_DSS database was damaged two times and had to be reconstructed each time. It is not clear what caused the database damage, but clearly, it occurred during normal use of the COMB_DSS. The upgrade from R:BASE 3.1(c) to 4.0 seemed to alleviate the problem. A backup capability was provided with COMB_DSS to ensure the restoration of the RBASE .RBF files. However, the non-.RBF BitMap file should have also been included in the backup process. During the prototype test, the BitMap file was accidentally overwritten after the backup procedure had been performed. All the scenarios had to be rerun, which consumed the better part of one workday.

Almost all of the features of the COMB_DSS system were thoroughly used at one time or another during the prototype test. The primary capability of ranking scenarios was not used in the prototype test as anticipated by the development team. In an effort to accomplish ranking as it was accomplished in previous years, the ranking feature of the COMB_DSS was based on recommended budget scenario only. The COMB_DSS has the capacity to rerank work functions based on Division rank, but decision makers chose to use HQUSACE rank when finalizing the recommended budget scenario.

Organizational Issues

Effective use of the COMB_DSS requires a working institutional knowledge of policy and procedure at Civil Works HQUSACE level. The COMB_DSS system provides the capability necessary to make decisions during the O&M budget allocation process. The overall concept was clear to the end-user, but there was some ambiguity with regard to formulation of scenarios and how scenarios are related. Strategies for scenario formulation need to be identified before using the COMB_DSS. Even for an experienced user, the COMB_DSS requires a certain degree of instruction and training. A useful feature would be to indicate which scenarios are primary and which are part of a composite when producing scenario reports.

The COMB_DSS training was conducted at HQUSACE just prior to the applying the evolved prototype to the 1994 O&M budget submittal. During preliminary training of the COMB_DSS, several changes were identified and corrected within the space of a day. It was not possible to train the COMB_DSS end-user in detail given the approaching budget allocation process. Rather, attention was focused on comprehensive hands-on use of the COMB_DSS system and strategies for using COMB_DSS effectively.

The COMB_DSS prototype system has demonstrated responsiveness to HQUSACE requirements in several ways. The COMB_DSS allowed HQUSACE to perform budget submittals in a manner similar to that of previous years while remaining flexible enough to adapt to on-the-spot changes. The COMB_DSS, by design, does provide alternative methods of accomplishing the budget allocation process, which may be utilized in the next budget cycle. As mentioned previously, the formulation of the budget submittal was more scenario intensive this year than in previous years. Thus, the COMB_DSS demonstrated the capability to handle the information load quite effectively while reducing the cost of doing business dramatically.

5 Future Directions

Prototype Improvements

Although accounted for in design, the COMB_DSS will need to be modified to accommodate additional criteria analysis, such that ongoing research and related mathematical models (e.g., incremental analysis, where a serviceability index is being developed) that support ways of comparing two disjoint classes of work can be implemented with all necessary data.

Speed improvements will likely be a function of R:BASE (or other RDBMS environment that supports SQL) improvements and enhanced computer speeds. Other improvements will include consistency in keystroke handling, on-screen information, a context-sensitive help system, and additional analysis tools.

The initial design called for graphic reporting capabilities, but budgetary constraints, given the workload and the fact that COMB_DSS became "real" in later prototype stages, preempted their implementation. Graphics, implemented through a pre-existing software package, R:BASE enhancements, or custom development, are highly desirable for COMB_DSS stage II.

Additional analysis capabilities such as a statistical analyzer that affords the user meaningful information through data exploration and trend examination (e.g., comparison to historic data) are desirable in the next phase of development.

Given the desired COMB_DSS improvements, R:BASE will need to be reevaluated to determine if its current capabilities are sufficient. The question of porting the COMB_DSS to ORACLE or some other RDBMS environment on a mainframe or UNIX workstation will need to be further examined.

Distributed COMB_DSS

There exists the possibility of providing the Corps Districts and Divisions with a distributed version of COMB_DSS. This would require an examination of how various Districts/Divisions are performing budget submittals on the micro-ABS. Do they perform scenario analysis? With what tools? Given the complexity of the COMB_DSS and the knowledge of the end-user, a distributed system might well require significant changes in design. However, a distributed COMB_DSS will provide both HQUSACE and Divisions with more reliable data, and perhaps a lighter workload, by distributing the decision-making process to those closer to the actual work.

Other Potential DSS Applications

The COMB_DSS is a useful tool that allows HQUSACE to examine and analyze budget submittals by Divisions. A similar capability that addresses the expenditure of funds provided via the O&M appropriation is needed to provide a total picture for OCR managers about the disposition of funds. The database for such a DSS would be provided by the Corps of Engineer Management Information System (COEMIS) or the new Corps of Engineers Financial Management System (CEFMS). The development of a DSS that is able to analyze both budget allocation and corresponding expenditures is a future research item under the Decision Support System work unit within the IOMT.

6 Results and Conclusions

The development of the COMB_DSS under this scope of work was really "proof-of-concept" for the following items:

a. Decision support development tools are available.

b. The technical know-how available to develop DSS's exists.

c. Corps budget processes can be adapted to DSS methodologies and thinking.

The COMB_DSS was successfully conceptualized, designed, developed through iterative prototyping methods, and implemented. The success of this research effort can be attributed to the Corps personnel who were involved in the project and are subject matter experts on the O&M budget process. However, a better understanding of the COMB_DSS capabilities and constraints may have lead to more use of system capacities and less mimicking of the way scenarios are developed on the RAMIS system.

The COMB_DSS proved sufficiently fluid, such that requirements of decision makers were met. This could not have been accomplished without the rapid prototyping that followed ongoing changes to concept and design. There were many capabilities designed into the COMB_DSS (e.g., build SQL) that were not utilized at all during the O&M budget submittal. Although the design team sought to change the way the decision makers approached the problem, the desired system outputs were the same as those desired in previous years. However, the system was used to its potential through the development of over 250 budget scenarios (three times higher than in previous years) indicating that user demands will expand to system capabilities.

Appendix A Existing ABS System and O&M Budget Process

The O&M Budget Process

Overview

The Operations and Maintenance (O&M) account is one of five major programs that compose the Civil Works Budget for the Corps of Engineers. It involves a $1.5 billion annual work effort targeted at the annual identification and selection of approximately 850 projects from a total inventory of 1,400 projects. These projects are responsible for the maintenance of some 4,000 individual structures, managed by Corps District and Division offices. The budget cycle for any targeted budget year (BY) comprises 2 years beginning about January BY -2 with a cost estimate of individual tasks, drawn up at the project site or appropriate organizational element within the District office. When the individual tasks are grouped into work functions, there are 20,000 separate units that make up the budget requests submitted to Congress for annual fiscal appropriations. The budgeting process allows for adjustments that might occur due to shifting administrative priorities or unexpected emergencies requiring immediate unanticipated reaction. The Corps O&M program execution goals are to physically complete the funded work effort in the President's budget together with any Congressional add-on, while expending 95 percent of annual appropriation.

Cycle description

The O&M budget process consists of managers at various hierarchical levels as shown in Figure A1. Each manager is responsible for formulating a set of work functions for consideration at the next higher level. The flowchart in Figure A1 depicts an upward passing of the budget request to higher managerial levels, Congressional appropriation at the summit, and a reverse downward flow to represent the allocation of funding resources. The chart also illustrates a minimum of 2 years to complete this cycle, from BY -2 to the actual BY. There are four levels of review within the Corps, through which priorities are set for work functions.

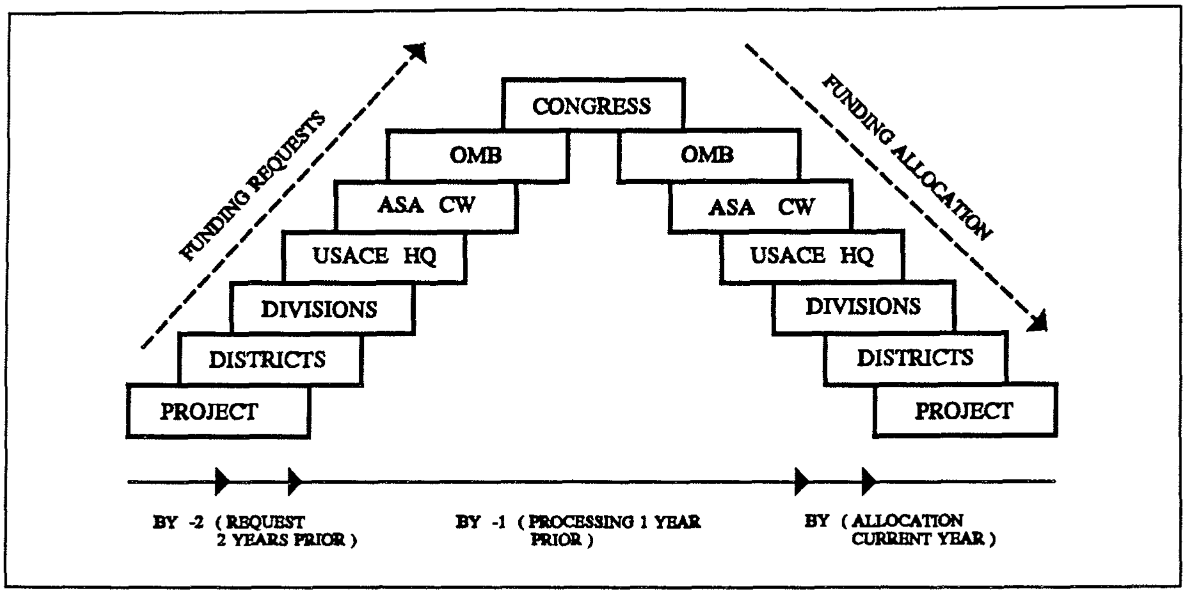

Figure A1. Hierarchy of management

The senior management at the Headquarters level (HQUSACE) recognizes that a nonuniform working structure exists at the field level where decisions are made to rank and fund O&M projects. Although guidance in the form of regulations drives the O&M budget process, the specific manner and methods for making allocation choices are not prescriptive of internal Corps policy. Each District and Division appears to have taken a unique stance that is centered upon a combination of mission orientation, organizational structure, national socioeconomic objectives, regional considerations, and other factors.

Various factors hinder the smooth flow of the O&M budget process. For example, emergency dredging during flood and drought events represents an urgent situation that requires immediate adjustment. There is no separate fund available to pay for these emergency operations, and the money must be channeled from previously allocated O&M fiscal resources. Another problem results from differences in O&M workload priorities as assessed by field operating offices. Evaluation methods currently lack consistency. Furthermore, there are always limited funds, thereby forcing a cutoff line to be drawn within the list of maintenance requirements.

The Corps is challenged with growing maintenance requirements and also escalating operational costs. The inventory of projects is increasing annually due to the maintenance requirements of both new projects and older projects approaching the ends of their design lives. New operational considerations associated with social and environmental issues that were not present when projects first became operational are now adding to the costs of operation. There is a need for uniform efficiency that would standardize comparison among work in different categories. Benefit-cost assessments would improve decisions within a specific mission area, such as flood control or hydropower. However, competing projects across different mission responsibilities present an added dimension to the evaluation process. Multiple analytical methods must be considered in designing a weighing system that brings equilibrium to multiple goals.

The Automated Budget System

Historical development

The O&M budget was originally prepared in accordance with the principle of zero-base budgeting. The system originally designed to implement this principle greatly improved the process by ordering budget requests from the field offices. Work grouped together in decision packages was ranked according to its criticality first by the District offices, then by the Division offices, and finally by CECW-OM. Because all decision packages were prioritized, CECW-OM could develop an optimum program mix within authorized funding levels.

This original system was not sufficiently flexible to handle the diverse programs and activities that make up the O&M appropriations. A program is an area of activity related to a major mission of the Corps of Engineers, e.g., recreation, power generation, navigation, or flood control. Frequently, work functions from different programs were placed together in one *decision package*. When decisions made about a specific program resulted in the reprioritization of work in that program, a disaggregation of decision packages containing the work was necessary. Consequently, decisions on Corps-wide programs were difficult to implement.

The current Automated Budget System (ABS) attempts to correct those early difficulties and to facilitate the making and implementation of budgetary decisions. Work functions are no longer grouped together into decision packages but are treated as separate *decision units*. Work functions are categorized according to their respective programs and finance and accounting feature cost categories. If work within a program needs to be reranked, changes to the ABS do not require extensive updates.

ABS characteristics

Description of the ABS. The ABS is an upward reporting system executed within the U.S. Army Corps of Engineers. It serves as an administrative tool for the annual preparation and submission of the O&M budget to the Office of Management and Budget (OMB). ABS was designed primarily for decision support in the formulation of the O&M budget submittal and continues in that role at the present time. The system makes use of a fourth-generation language, RAMIS II, therefore enabling decision makers to run standard reports and ad hoc queries that determine the impacts of different budget scenarios on the O&M program.

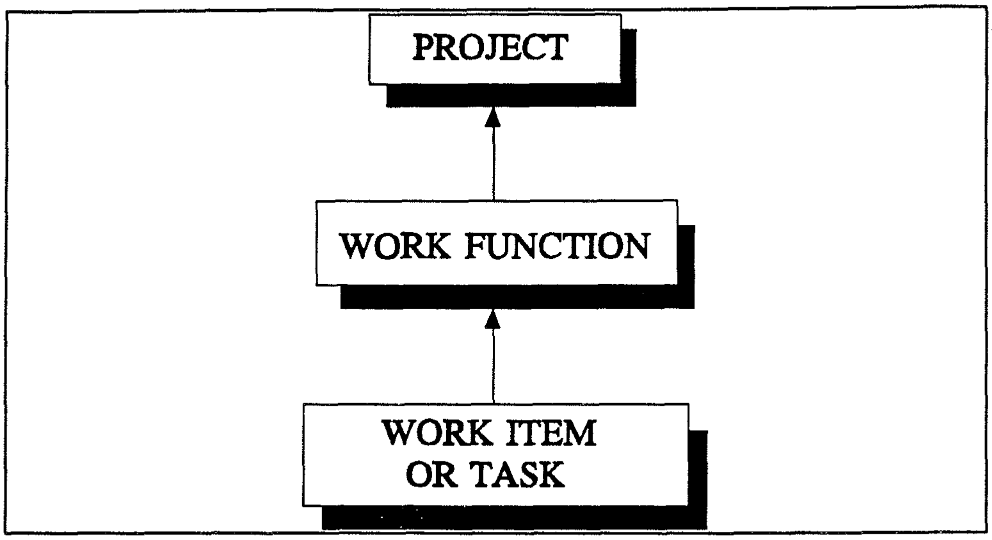

Figure A2. Work classification hierarchy

The *work item* or *task* (Figure A2) represents the lowest level of input information in the system structure. This is the most disaggregate level and pertains to a discrete activity that will be started or completed within a budget year (e.g., painting a lock gate). These work items can be aggregated into *work functions* depicting general areas of work. This is the second level of hierarchy, and during this phase, work functions are categorized in accordance with guidelines set forth in the performance level matrix in Engineer Circular (EC) 11-2-108.[1] Thus, work functions are prioritized and placed within their respective funding levels.

A work function is made up of a collection of O&M activities belonging to a program and representing a certain level of effort. A work function is identified by a specific cost code and funding level as specified in the performance level matrix. Decision unit funding analyses can be made on work functions without directly affecting other work functions. Work functions are assigned to one of 87 *work function categories,* which constitute the total work effort and correspond to the O&M feature cost accounting system. These categories are not rank-ordered and are, therefore, equal competitors for Congressional appropriation. Work functions within any specified category are subsequently graded against four incremental funding levels to establish their importance relative to one another. The levels of funding range from a minimum capability to an enhanced level of work effort across all categories of work effort. The four funding levels are described in EC 11-2-157.[2] Level 1 work functions receive the highest funding priority, while Level 4 work functions receive the lowest funding priority.

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1 Headquarters, U.S. Army Corps of Engineers. "Annual Program and Budget Request for Civil Works Activities, Corps of Engineers Fiscal Year 1984," EC 11-2-108, Washington, D.C.

2 Headquarters, U.S. Army Corps of Engineers. "Annual Program and Budget Request for Civil Works Activities, Corps of Engineers Fiscal Year 1992," EC 11-2-157, Washington, D.C.

The *project* occupies the top position in the work classification hierarchy. All work functions must belong to a specific authorized O&M project. A project represents completed construction of one or more major civil works structures, such as a lock or a dam or a flood control reservoir, that is being operated and maintained through O&M budget funds. Each project is specified by a name (assigned by authorizing act) and a Civil Works Information System (CWIS) number.

Management levels. There are four levels of internal management and review in the Corps O&M budget process: project or organizational element, District, Division, and HQUSACE (Figure A3). Four stages can be

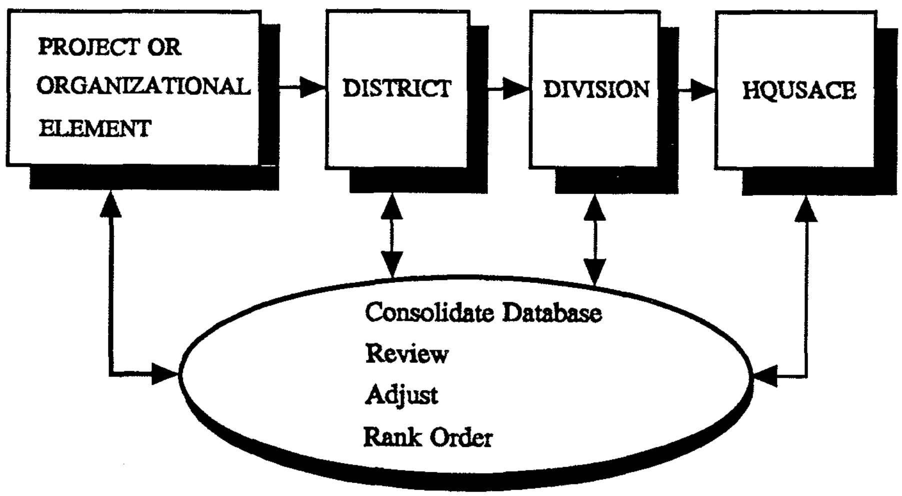

Figure A3. Levels of internal management

demarcated within each level of review in the budget preparation process. The first stage begins with the creation of a consolidated database consisting of incoming work function information. This is followed by review, adjustments, and finally a rank order.

Funding levels and classification. To provide a uniform approach to program development and justification, four incremental funding levels are defined and implemented. These levels are ordered with the smallest level number, 1, being the highest priority and 4 being the lowest priority. Thus, operation and maintenance of a navigation lock would be included in Level 1 while less critical enhancements or improvements would be placed in lower levels (e.g., 2, 3, 4). Funding levels are grouped by specific categories, as listed in Table C.2.1 of EC 11-2-157.[1] Table C.2.2 of EC 11-2-157[1] shows each category and each item listed by level.

A work function can be a single task or group of equivalent tasks by definition. Priorities will be assigned to each work function. Ranking of individual work functions is based upon field discretion within each level. No ranking across levels is allowed. Thus, all work functions for Level 1 are ranked only for Level 1, Level 2 work functions are ranked only for Level 2, and so forth.

The criteria for placing work functions in each of the four funding levels are included in Table C.2.2.[1] Following is a brief description of each funding level:

a. Level 1, the minimum funding level, is limited to ensuring public health and safety and a reasonable return of economic and other benefits from the existing investment and minor or ordinary repairs at high-use projects with mainline benefits of flood control, municipal and industrial water supply, commercial navigation, and hydropower.

b. The second level allows initiation of funding for other operations consistent with reasonable user needs as well as increased maintenance to assure adequacy of project features and integrity of structures through the budget year.

c. The third level of funding is considered O&M effort consistent with normal and customary operation of project features and at a cost approximating that of the previous budget year.

d. The fourth level provides for enhanced operations and maintenance above the current level. It more fully operates and maintains all projects with high economic benefits to a standard of excellence by providing for replacement of equipment for highly efficient operation and by eliminating most navigation delays.

Figure A4 shows the general progression of work tasks through the O&M budget process using the ABS.

ABS ranking. The Corps-wide database is the final aggregation of O&M budget information, and is created from integrating and consolidating the Divi sion databases. The Division databases are a consolidation of the District

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[1] EC 11-2-157, op. cit.

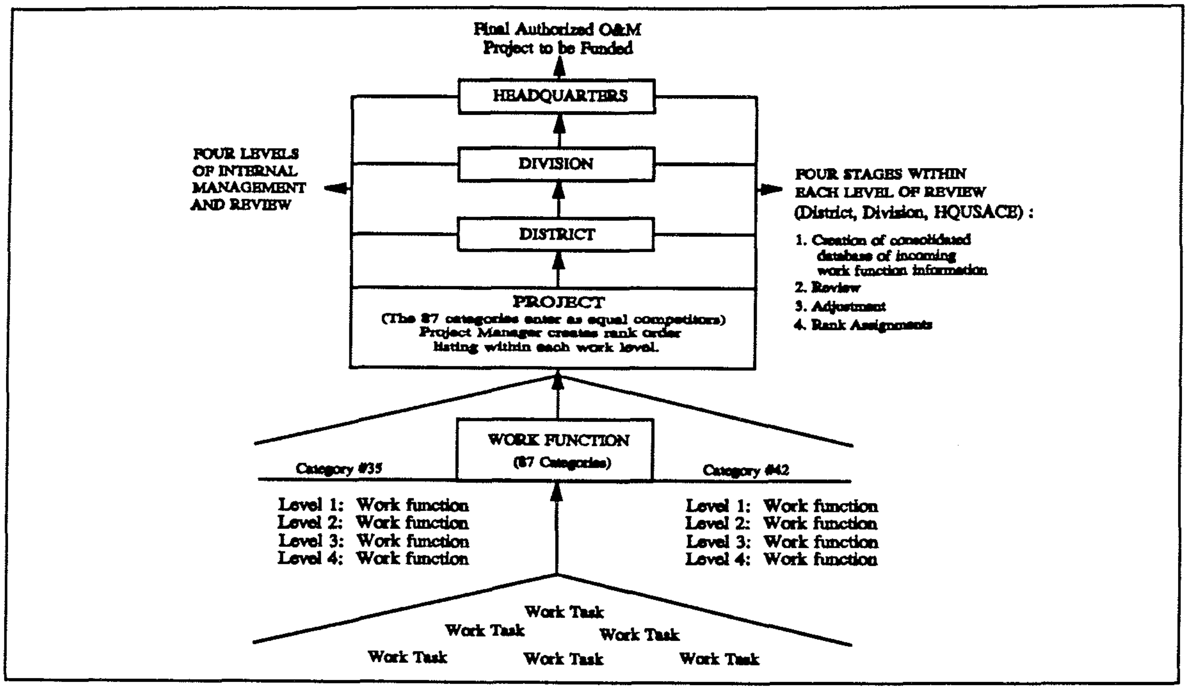

Figure A4. Work classification and the ABS

databases, which are edited and re-ranked in accordance with Division priorities. As discussed previously, before prioritizing, ranking, and integrating work functions at the District and Division levels can occur, a category and funding level must be assigned.

A computer program written in C-language was created by HQUSACE to facilitate the automated database integration and consolidation process. Starting with Level 1, the first work function for each Division (or District) is prioritized in accordance with its respective category. The work function with the highest priority relative to the other Division competitors is then placed into the consolidated database. The next work function is then pulled from that Division to compete with the existing work functions and the process is repeated. When any Division extinguishes 10 percent of its total share in a given level, it is placed on *hold* until all of the other Divisions have extinguished 10 percent. This process continues until all Level 1 work functions have been placed into the consolidated database. Levels 2, 3, and 4 are processed in the same manner as Level 1.

This method is fair to both Divisions and Districts, since the integrity of the priorities set by either entity is preserved. The consolidated database can be pictured as an empty box, being filled as described. Once full, it is flipped over, and at the top are the Level 1 work functions, followed by the Level 2 work functions, and so forth. Although all of the Division work functions are integrated, they still maintain their original rank order. This procedure attempts to eliminate any bias potential of this type of data integration. Figure A5 shows the HQUSACE ranking procedure.

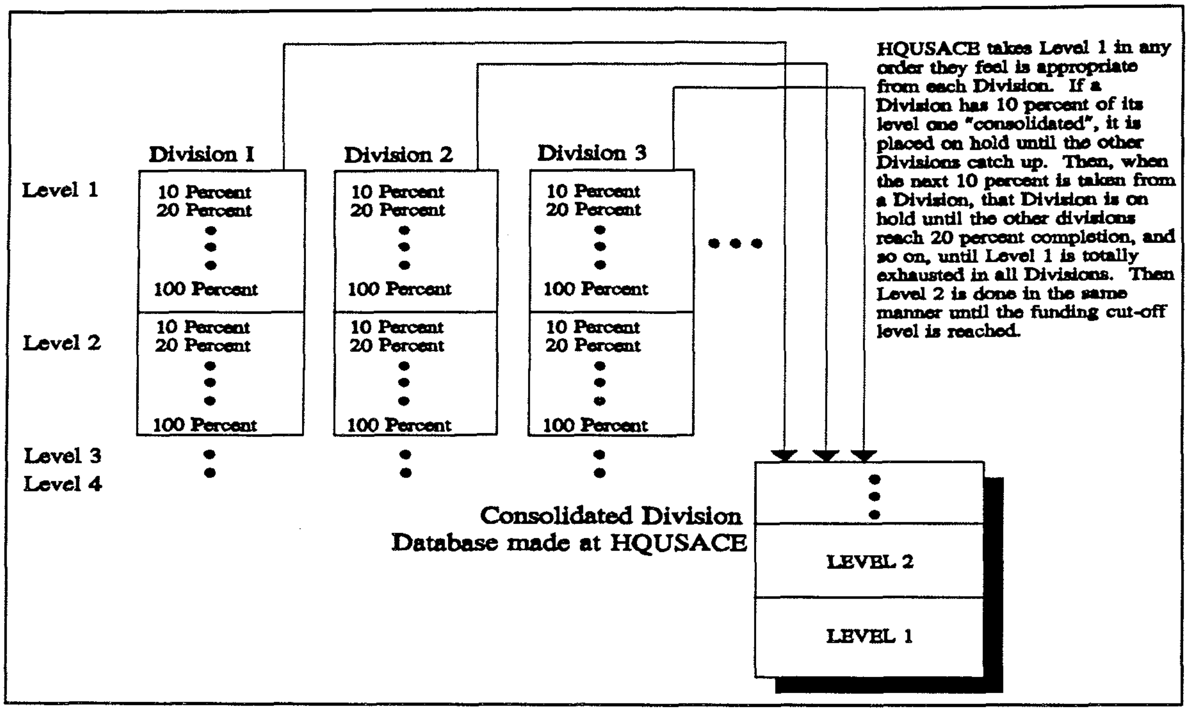

Figure A5. HQUSACE ranking procedure

The automatic ranking process is a good way to obtain an initial rank of work functions within a funding level. Although Divisions and HQUSACE have the option to use the automatic ranking procedure, Districts do not. Thus, Districts must use a manual ranking procedure. Division offices are encouraged to review the initial rank assignments and manually adjust them to ensure a well-balanced program that provides a justified level of service for all projects. HQUSACE must make extensive manual adjustments to its automatic rank assignments both individually and programmatically to produce a balanced nationwide program.

The rank for any work function is a five-digit number for the Divisions and Districts, and a seven-digit number for HQUSACE. The first and leftmost digit for each rank number always corresponds to the funding level. The remainder of digits are sequenced by order of importance in increasing order for each funding level. Typically, each number in the sequence will differ from the last by two or three. This allows room for the integration of additional and/or changed work functions at a later point in time. HQUSACE uses a seven-digit number because (a) they must rank all of the District and Division work functions together; and (b) they typically keep particular work functions logically grouped using the fourth and fifth digit in the rank number.

The ABS/O&M interface

The interface between the ABS system and the O&M budget begins with a Corps-wide meeting involving the Districts, Divisions, and HQUSACE.

During this meeting, which is generally held by March BY -2, HQUSACE gives specific budget guidance and each Division receives a target budget to guide their internal rankings and decisions. During this time, ABS training may be held for the Districts. If there are any changes to the ABS system, they are announced, explained, and implemented. The events that precede and follow the meeting are discussed in the following paragraphs and are represented in Figure A6.

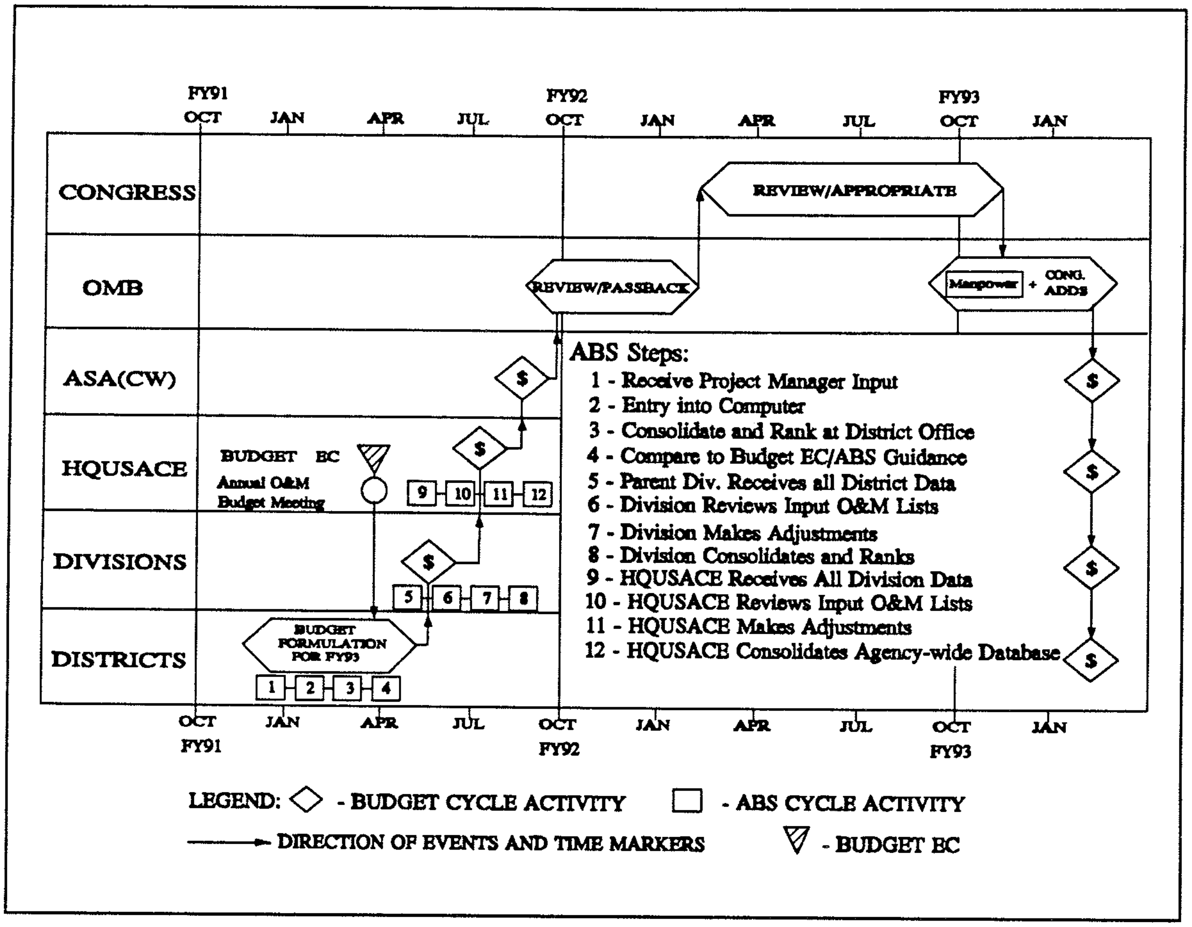

Figure A6. O&M budget cycle and ABS activities

As early as January, each District has on-site project managers compile a list of work items to accomplish in the budget year at the project level. The District then reviews project level information, makes a few initial adjustments, and adds new project records. After updating in late March to early April, the District ranks work functions by order of importance and assigns them to a funding level by category.

The District summarizes work item information for each work function to include such items as contract costs, supervision and administration costs, and estimated dredging. The work is entered into local microcomputers and uploaded to the Washington Computer Center (WCC) by mid-May.

From mid-May to mid-June, Division databases are downloaded from WCC to local microcomputers. District budget submittals are reviewed, adjusted, and uploaded back to the WCC mainframe. District offices may then contact the Division office to dispute any adjustments they feel are questionable. Any necessary adjustments are made to the Division database prior to Corps-wide integration.

Sometime between June 15th and July 15th, HQUSACE consolidates each Division database into a single agency-wide database using the ranking process described previously. To this end, the District and Division offices may review any adjustments made by HQUSACE. After negotiating sensitive adjustments, the consolidated database is revised. Toward the end of July, HQUSACE submits the budget proposal to the Assistant Secretary of the Army (ASA) for approval. Changes are then made to the database as dictated by the ASA.

By September 1st, the Civil Works Operation & Maintenance Budget is presented through the ASA, Civil Works (CW), to the OMB, and is then returned to HQUSACE by late November. In December, HQUSACE requests Divisions to prepare "Justification of Estimate" sheets for presentation to Congress after OMB has given the Corps its final program.

Starting late January to early February, representatives from each Division are sent to justify their budget before Congress. These representatives use information generated by the ABS reports to answer questions brought before them during the hearings on Capitol Hill. Congress will deliberate on the testimony of these representatives and pass an appropriations bill in October of the BY. The funds are then distributed to the District for obligation and expenditure.

Example

This example illustrates the process that work tasks undergo before funding. A work task (e.g., painting lock gates at Facility A) is tracked from the initial request for funding to ultimate receipt of the funds, as a work function. Currently individual tasks are not tracked from the initial request to the receipt of funds. However, the District Operations & Maintenance Budget System is working toward getting data distributed to this level.

The request for funding begins at the project level with a work task, which is the smallest unit of work at a Corps facility. For funding purposes, similar work tasks are normally pooled together into a work function by the Project or Area Managers. Not all work tasks are necessarily aggregated into a work function because some tasks are unique and can stand alone, such as backup generator maintenance at a Corps dam. In this example, painting the lock gates at Facility A and painting the lock gates at other area locks might be combined into a work function. This work function is placed into a proposed O&M budget request that is sent to the District. There, these work functions are assigned funding levels according to their importance to the project's mission and are placed into one of 87 work function categories (such as Lock Operations). These assigned funding levels range from 1 to 4, with Level 1 representing those work functions critical to the mission of the project, and level 4 representing work functions that provide enhancement of the project but are not critical to its mission. Thus Level 1 items will receive funding before a Level 2 item. Maintenance of a backup generator at a Corps dam may typically receive a Level 1 assignment, the painting of a lock gate may receive a Level 2 assignment, and painting picnic tables at a Corps recreation area may be assigned to the fourth funding level. These assignments are conducted at the District level and are based on the Performance Level Matrix guidelines provided in EC 11-2-108.[1]

After each work function is assigned to a funding level, it is evaluated and ranked again within each funding level. For example, painting the lock gates at Facility A may have received a Level 2 assignment, as did the painting of lock gates at all other locks in that District. To compare these Level 2 work functions, they will be given rankings such as 20000, 20010, 20020. Therefore, a work function given the ranking of 20000 will have greater funding priority over a work function given a 20020 ranking. Although each O&M manager ranks all work functions within a funding level, it does not mean that each work function is from the same category. For example, a manager may have to directly decide the rank of a lock gate getting painted against a rest area being maintained.

The challenge for the O&M manager is to rank-order all Level 2 work functions within a given category. Similarly, he or she must also rank order all work functions (or separate work tasks) for each funding level within every category. This means that the manager who has multiple functions that fill all 4 levels of all 87 categories must satisfy 4 x 87, or 348, decision points to complete rank-ordering. Of course, it is likely that the District O&M manager has work functions for only some of the 87 categories, and the choices and rank ordering challenge are reduced, but still complicated.

In this example, suppose Facility A has had the painting of its lock gates postponed for several funding cycles. Another facility (Facility B) may have had its lock gates painted recently, but for the purpose of routine maintenance funds are requested again for this activity. Facility A may exhibit greater need; therefore painting Facility A's lock gates might receive a ranking of 20000, while painting the lock gates at Facility B might receive a ranking of only 21000. Once these work functions have been rank-ordered in their respective funding levels by the District, the information is then uploaded through the ABS to the Division for consolidation with the other District databases.

The process of database consolidation, review, adjustment, and prioritization occurs at the District, Division, and HQUSACE level. The amount of reprioritization decreases as the O&M budget request moves up the management

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1 Op. cit.

hierarchy through the ABS to HQUSACE. At each level, a work function from one category competes against work functions from all other Districts in a Division, and then against all Divisions in the Corps. Once the budget request arrives at HQUSACE, the process of aggregating all previously input work functions begins. Not all work functions entered will receive funding. An issue of major importance to local managers is the location of the funding cutoff line established by HQUSACE. Due to budgetary constraints and increasing maintenance needs, the cutoff line for funding has shifted to a point somewhere within Level 2.

Remembering the notion of a cutoff line, and referring to Figure A7, all Level 1 work functions in the 87 categories will be funded, as well as those at Levels 2a and 2b. This suggests that the cutoff line is going to be drawn somewhere in Level 2c. The work functions in Level 2c above the cutoff line will be funded, but the Level 2c work functions below the cutoff line will not receive funding. The work functions at Levels 3 and 4 will also be excluded from funding unless exceptional circumstances and/or appropriate justification are submitted by the requesting District/Division and approved at HQUSACE. Therefore, the painting of Facility A's lock gates will receive funding due to its rank of 20000. However, what happens to Facility B's request for painting of its lock gates? Since it has a ranking of 20260 and the cutoff line is drawn within that level, it may or may not receive funding. The category to which this 2c work function belongs may affect its placement above or below the cutoff line. Although Corps regulations emphasize that the funding postures of the categories are equal, the President's budget guidance does create an arrangement of the categories. Of the 87 competing categories, some may receive more emphasis due to the policies of the current Administration. In other words, in any fiscal year, one category may become more important than another. A category becomes essential in the ranking process only when two work functions from different Districts/Divisions have been ranked in the same area within the funding level.

Each Division receives funding for those projects above the cutoff line. The Divisions allocate this money to the Districts according to the costs for performing Level 1 and 2a, 2b, and some 2c work functions. The Divisions and Districts retain some necessary flexibility in allocating the money they receive. This flexibility is important because money may have to be diverted from work functions that received funding in order to address unforeseen circumstances. Keep in mind that it will have been 18-24 months since the original budget request was submitted, and time may have altered intended events. An adjustment of funds may occur when conditions at the facility change, emergency situations arise, or "slippage" in work occurs, wherein not all the allotted money is spent as initially anticipated. This means that some Level 2c and 2b work functions may not receive money even though they were approved for funding at the HQUSACE level.

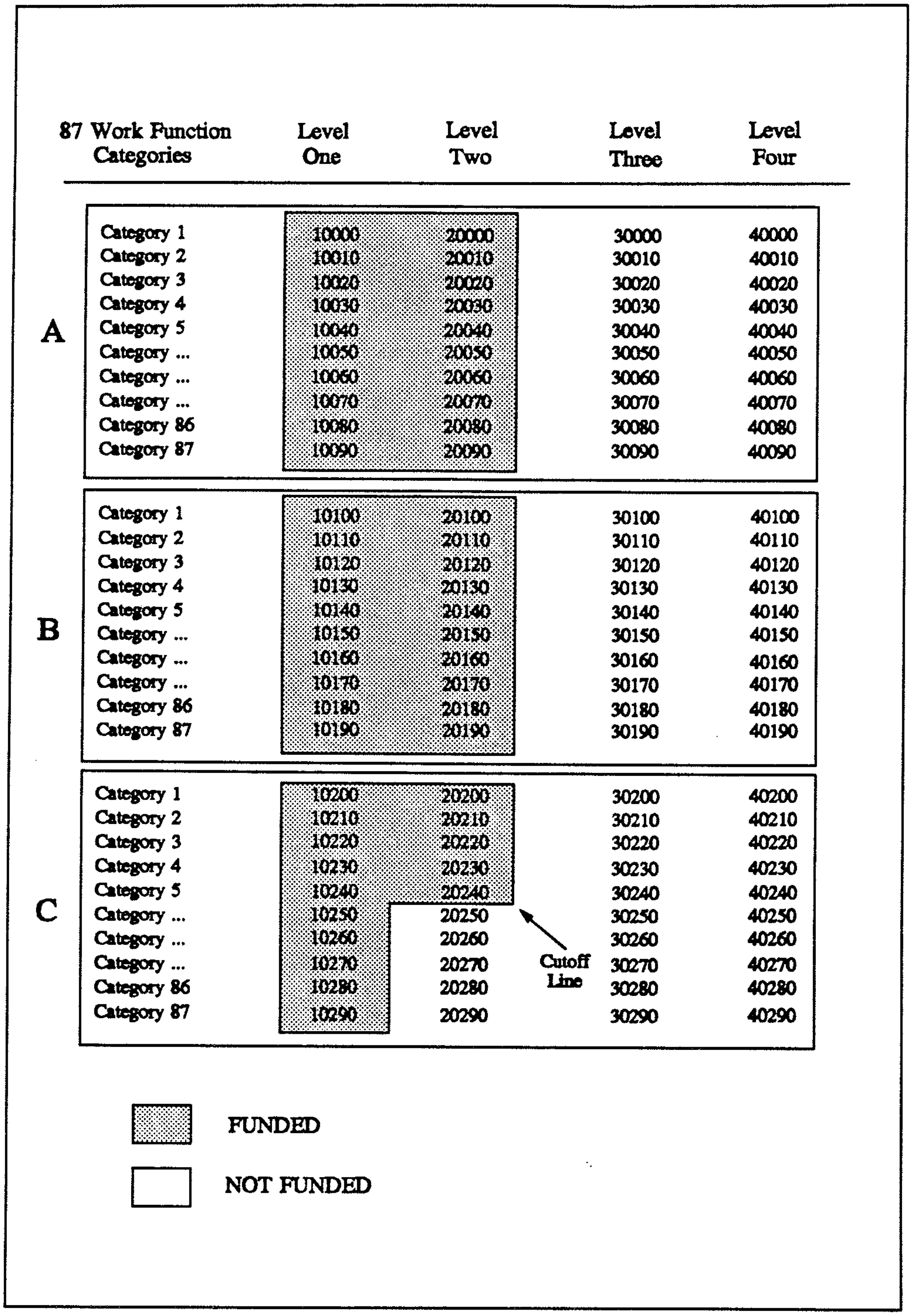

Figure A7. Hypothetical example of O&M funding process

Existing System Design

This section provides an overview of the hardware and software requirements of both the microcomputer and mainframe versions of the ABS. A discussion of the data structures, the functional relationships among tables, and available reports are provided for each system.

The micro-ABS program was generated using the Clipper 5.0 compiler. Clipper operates on the dBase III file format and offers a command set which fully encompasses that of dBase III. Clipper's added capabilities include many functions and libraries which allow creation of menus, pick-lists, data entry, and other types of front-end interfaces. Because dBase III formats exist in micro-ABS, "index files" are available which allow the ordering of data files by various criteria without the need to physically sort the file on disk.

On the WCC mainframe, the RAMIS II database management system handles data relationships quite like the personal computer version. Many reports are available on the mainframe as well as the microcomputers for managers of all levels. The relational data structures are ideal for data modification. An ASCII flat-file export capability facilitates file transfers from District and Division to HQUSACE.

Overview of system architecture

The ABS is characterized by an intricate network of computer systems at all user levels of review. The basic operations of the O&M budgeting process can be executed through mainframe/minicomputers, and microcomputers using ABS (see Figure A8). This network is available at the District, Division and

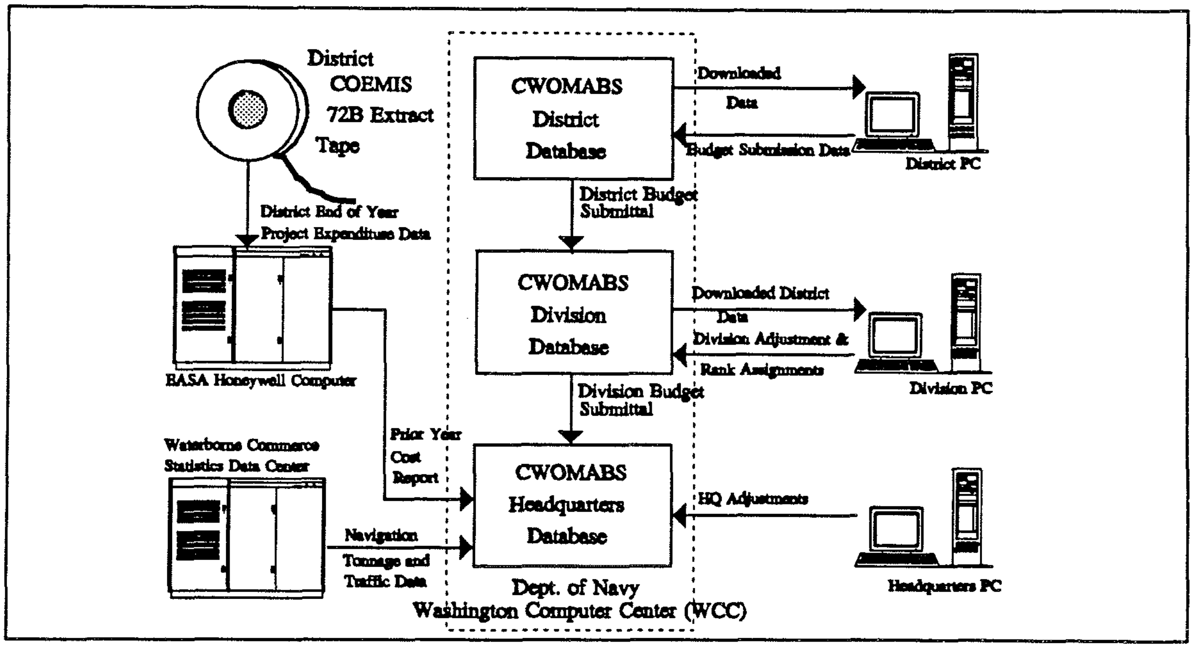

Figure A8. Computers used for the O&M process

HQUSACE level. The District update begins with the creation of a District database on the WCC mainframe computer. It is then downloaded as work function data to District microcomputers for data update. After completion of the update, the District data are exported to a single file, and uploaded to the WCC mainframe computer.

District databases are consolidated into the Division database on the WCC mainframe. The Division can then download and review its own database for adjustments and prioritization. Data adjustments and ranking are facilitated through micro-ABS, which also provides a way to download and upload the data. This process can occur many times prior to the cycle date, at which time the projects are presented to Congress and the funds are appropriated.

Telecommunications between the microcomputers and the WCC mainframe are accomplished using the Kermit protocol. This protocol is simply a "modem language" common to the microcomputer and WCC communication software.

Important information transfers

District information transfers. Beginning with the 1989 budget submittal, District offices use microcomputer systems to access, update and submit budget data. This is a five-step process designed to be simple yet able to accommodate the full range of computing and communications hardware used in District offices.

First, the District database is created, using a menu of options to create a single file on the WCC mainframe computer, otherwise known as the Navy Regional Data Automation Center (NARDAC). Figure A9 shows how District data are processed and transferred to and from the WCC/NARDAC.

Second, the budget data are imported from a single file into the ABS. Third, it is then modified on that microcomputer, or other microcomputers in the District. When modifications are complete, the process turns around.

Fourth, the data are exported from the micro-ABS to a single file. Micro-ABS automatically adds job control language to the file upon export. Fifth, using communication software and the Kermit protocol, the budget upload file is transferred back to the WCC mainframe.

After a District office has completed updating and uploading its budget submission database, they may continue to make changes on their microcomputers. Then they upload only that part of the database that contains the changed work functions. The uploaded information is then incorporated into the mainframe District database by running several available edit and load programs. These edit and load programs will produce a set of error reports for review and adjustment by District personnel. Also, each District/Division can run reports on the WCC system to verify the accuracy of the established or updated database.

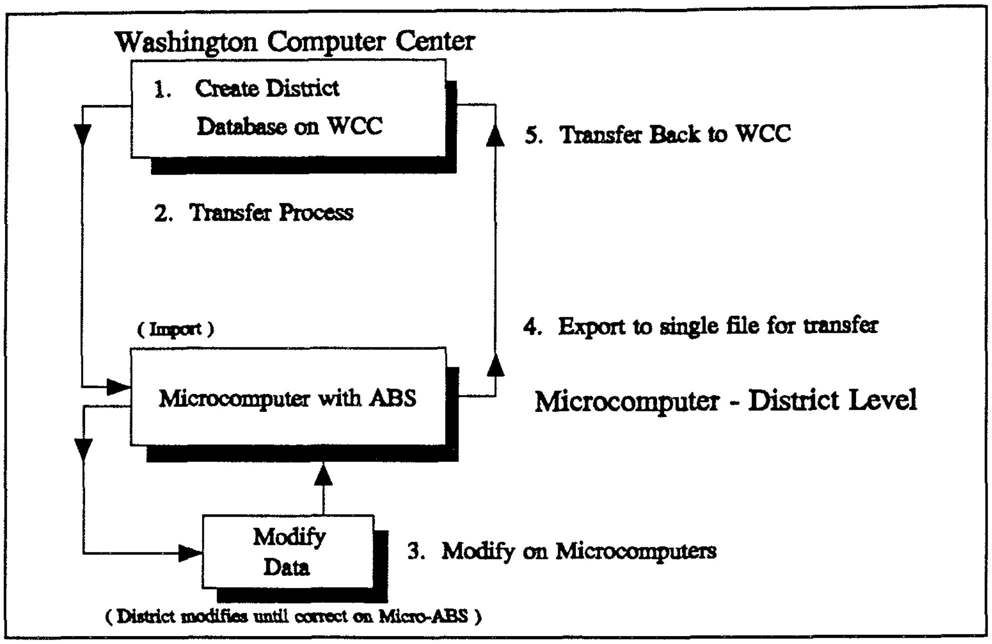

Figure A9. Data transfer, District/WCC

After each District database is established and verified, the Division office is notified that the District's submission is ready for review. The Division office uses the standard reports available from the WCC District Main Menu and RAMIS II ad hoc queries for reviewing the individual District databases prior to establishing the Division database. Correspondence between the Division and Districts is generated through the Programs Management Office or other established directorates to resolve differences noted in each District database. Division comments and Districts rebuttals are established to resolve conflicts in the District's budget submission. Any District/Division interaction not resolved using the rebuttal method of checks and balances is continued after the Division database is established.

Division information transfers. Beginning with the fiscal year 1990 budget submittal, Divisions review and adjust their budgets in much the same way as the Districts. After the District databases have been uploaded to the WCC and District/Division personnel have run reports to ensure that the District databases are correct, CECW-OM will consolidate the District databases into the Division database. The Division may then log on to the WCC and download the consolidated database for review and adjustment.

Once the Division database has been established, it is prudent for the Division to run whatever mainframe reports necessary to ensure that a usable database has been created. After the Division database has been created and prior to downloading, the Division may elect to have HQUSACE run an automatic ranking program to assign initial rankings to work functions on the Division database on the mainframe computer. Then the database, complete with proposed adjustments, is returned (uploaded) to WCC. Figure A10 depicts data transfer between Divisions and WCC.

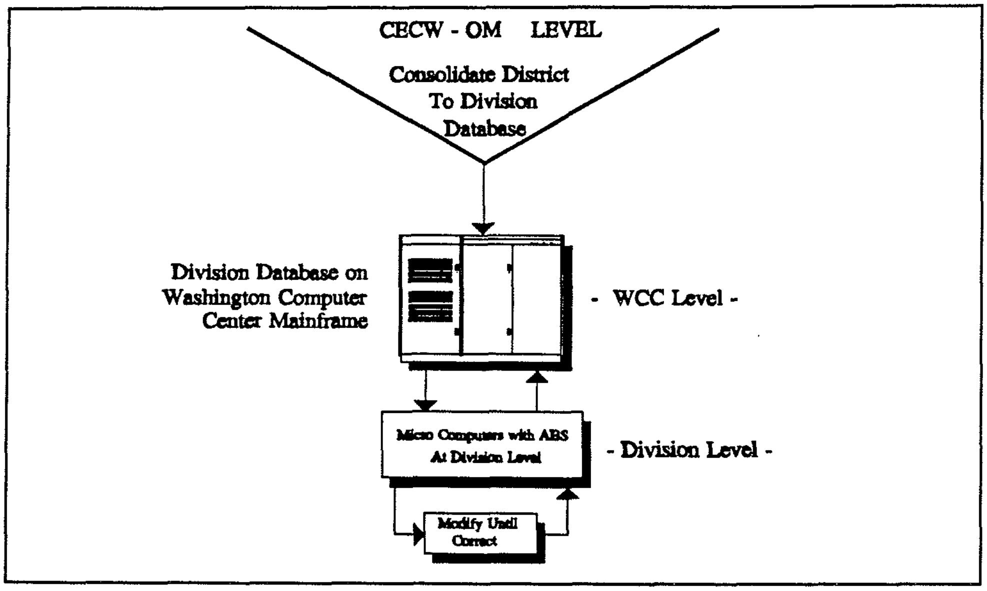

Figure A10. Data transfer, Division/WCC

Like a District, a Division may make more than one upload. The Division may, at its discretion, use this feature to allow the Districts to review Division revisions to their budgets before the CECW-OM database is created. When the Division uploads to the WCC, adjustments will be written to a separate file, as well as to the Division database. The Division may then elect to have the Districts run a correction report against the budget year Division database and make comments. The Division always has the option to make changes on its microcomputer database and re-upload.

HQUSACE information transfers. HQUSACE adjustment and ranking procedures on the computer are essentially the same as the Division office's procedures. HQUSACE creates a consolidated Corps-wide database by combining data from all Division databases. When adjustments are made, they are put into a file that can be accessed by both Division and District offices. Adjustments are not applied to the HQUSACE database until Divisions have had a chance to rebut them. After the ranking process has been completed at HQUSACE, the Corps-wide database is made available to all District and Division offices so they may run reports to determine the status of their budget. Refer to Figure A6 for a time cycle depiction of the O&M budget process activities along with the most important ABS cycle activities.

System environment

Microcomputer requirements. Micro-ABS requires a microcomputer with a modem, capable of at least 1200 baud communications. Along with the five installation disks for micro-ABS, a communications program called Procomm is included. Other communication programs may be used instead of Procomm. However, the Kermit protocol must be used to accomplish correct communications with the mainframe. It is recommended that the microcomputer have at least 640K memory. Printers are optional but recommended.

In the past Harris minicomputers played a large role in the data transfer mechanism. The Harris minicomputers were typically distributed to each District. Those Districts without a Harris could utilize one at an adjacent District. Since the Harris is no longer required in the O&M Budget Cycle process, they are not discussed in detail. Districts still have the ability to download files to the Harris. This allows them to utilize the high-speed printers available. This is useful for those reports that tend to be very large. Figure A11 shows the general hierarchy of computers and their uses, including the Harris computers.

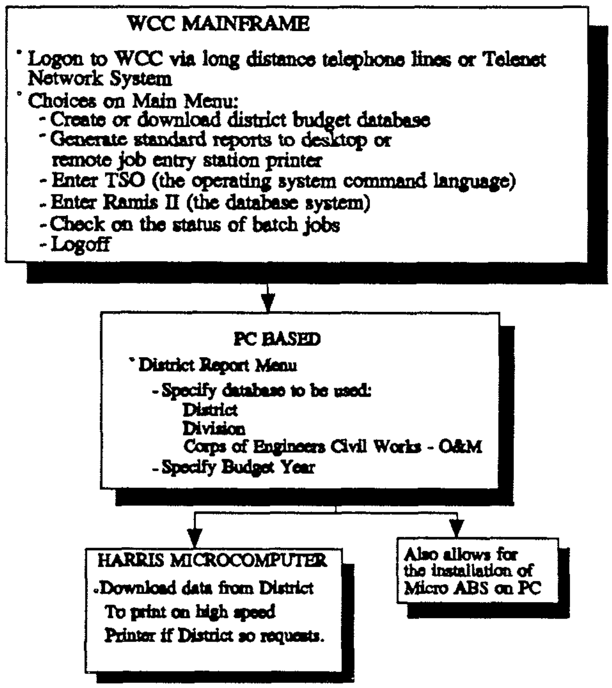

Figure A11. ABS computer hierarchy

WCC mainframe requirements. The WCC mainframe is from Hitachi Data Systems and has an XL/80 production processor. This mainframe is designed to be an IBM clone. Thus, IBM mainframe software and hardware can be utilized. The communication parameters are as follows:

Baud rate	1200, 2400, 9600
Data bits	8
Stop bits	1
Duplex	Half
Parity	None

The RAMIS II database management system software is a product of Online Software, Inc. RAMIS II is a complete fourth-generation database management system with its own native language. The COBOL programming language is used in update programs, where edit checks are required before data are entered into the database file. All of the standard reports and ad hoc queries are written in the RAMIS II ad hoc query language and the RAMIS II SBX procedural language.

System structure

Micro-ABS relational structure. The micro-ABS has 9 major database files and 22 different index files. A database file may have up to 15 active indices (Clipper Constraint). However, none of the ABS databases contain more than 10 indices. Following is a brief description of these data files and the corresponding index files. As mentioned previously, these index files allow the databases to appear sorted according to the index file's "index key." The index keys for each index file are also listed to show the different ways that data can be sorted and printed by the micro-ABS program. Table A1 shows the actual data files and index file(s) for each. Appendix B lists the fields for each data file.

Note that the index files denoted with an * are temporary. Temporary indices are for reporting or using other features that do not require the index for proper micro-ABS execution. The "STR()" indicates that a numeric field is converted to a character field. This allows micro-ABS to have both a character field and a numeric field together in a single index key.

Key fields such as APPROP + PRJNAME are compound keys (e.g., the database has primary and secondary sort fields). In this example, APPROP is the primary sort field. This makes all data in a database appear to be in order by the APPROP field. When there are multiple records with the same APPROP field entry, a check is done on the secondary sort key, in this case PRJNAME. There may be many secondary keys, as shown by several of the indices listed in Table A1. There is no set relationship between the database files. Any database file containing the same field as another can be interrelated by virtue of an index file with the common field setup as the primary key.

WCC RAMIS II ad hoc queries. The query language that comes with the RAMIS II Database Management System is a powerful fourth-generation language that allows the creation of reports with user-friendly commands. A minimum amount of training is required to generate most simple reports. A training course is periodically offered by On-line Software for those interested in learning more data-intensive report generation.

Table A1
Micro-ABS Data Files and Indices

Database	Index Files	Index Key
CATFEAT.DBF	CATFEAT.NTX	FEATCODE + CATCODE
	*CATEMP.NTX	CATCODE
CATEXC.DBF	CATEXC.NTX	CATCODE
CE_COST.DBF	CE_INDEX.NTX	STR(YEAR,2) + STR(CWIS,5) +
		STR(FUNCID,4) + CE_FIELD +BREAK_FLD
NAV_DET.DBF	NAV_DET.NTX	STR(CWIS,5) + STR(REACH,4)
NAV_PWW.DBF	NAV_PORT.NTX	STR(CWIS,5) + STR(REACHID,4) +
		STR(WWCODE,4) + STR(PORTCODE1,5)
	NAV_PWW.NTX	STR(CWIS,5) + STR(REACHID,4) +
STR(WWCODE,4)		
ORGFILE.DBF	ORGINDEX.NTX	ORGCODE
PRJFILE.DBF	PRJINDEX.NTX	STR(CWIS,5)
	*PRJPCCW.NTX	PRJCLASS + STR(CWIS,5)
	*PRJPCPN.NTX	PRJCLASS + PRJNAME
STATEFIL.DBF	STINDEX.NTX	STATE
WRKFILE.DBF	*WORGNFDR.NTX	ORGCODE + FUNDLEVEL + STR(DISTRANK,4)
	*WRCWNFDR.NTX	STR(CWIS,5) + STR(NUMFUND,1) +
STR(DISTRANK,4)		
	WRKAPP.NTX	APPROP + STR(YEAR,2) + STR(CWIS,5)
	*WRKCAT.NTX	CATCODE + APPROP
	*WRKCWFC.NTX	STR(CWIS,5) + FEATCODE
	WRKKEY.NTX	STR(YEAR,2) + STR(CWIS,5) + STR(FUNCID,4)
	*WRKNFDR.NTX	STR(NUMFUND,1) + STR(DISTRANK,4)
	*WRKREACH.NTX	STR(CWIS,5) + STR(REACHID,4) + STR(YEAR,2)
	*WRKTAB1.NTX	APPROP + PRJNAME
	*WRKTAB2.NTX	STR(YEAR,2) + STR(NUMFUND,1) +
STR(DISTRANK,4)		

The RAMIS II query language consists of a number of simple commands that may be combined together in different configurations. There are seven basic commands that the query language recognizes:

a. Define Command (DEFINE). This command creates new data elements from values of existing elements. This command is useful when functions such as totalling, subtotaling, and other calculations are required.

b. Report Command (TABLE). This command signifies to RAMIS II to prepare a report. This command is used by itself, and is not used along with other commands.

c. File Identifier Command (FILE). This command identifies the file from which RAMIS II system will generate a report. For 1991, all budgetary reports use the file name OMB91 as the file identifier. The actual command used to identify the filename in RAMIS II would be FILE OMB91.

d. Display Verb Commands (PRINT or SUM). These commands indicate which data element values to display on the report. The field names entered are separated by the words "AND" or "OR" (e.g., PRINT TOTCOST AND DESCRIPT OVER PROJNAM).

e. Sequencer Command (BY). This command indicates the order in which data element values will be displayed on the report. It also sets a breakpoint for subtotal calculations. The values of each data element specified after the BY command determine the order in which the data elements on the PRINT and SUM command will be displayed. If two BY statements are used, the values of the data element in the first BY statement dictate the primary sort and the values of the data element in the second BY statement determine the secondary sort.

f. Selector Command (IF). In most of the queries written, it is desirable to display a small number of records from the database that meet certain criteria. The IF statement allows you to select records based on the criteria specified.

g. Query Delimiter Command (END). This command signals the RAMIS II system that the query definition is finished. The system will then begin to process the query request and produce the report.

Tentative Changes to ABS

This section currently describes two tentative changes to the ABS. First is the adoption of the condition index (CI). Second is the ongoing port or transfer of the ABS from RAMIS II on an IBM clone mainframe to ORACLE on a CDC computer. Each of these changes is further described in the sections that follow.

Condition index

The CI's are intended to provide uniformity and objectivity in making structural observations of similar facilities. The designed set of engineering observations is used in mathematical formulas to create a final CI. Thus, objective comparisons can be made between a navigation structure and a recreation structure. CI values range from 0 to 100. The range is composed of three zones, as follows:

a. Zone 1 = 100 - 70 and indicates excellent to very good condition

b. Zone 2 = 69 - 40 and indicates good to fair condition

c. Zone 3 = 39 - 0 and indicates poor to failed condition

The ABS contains a defunct field called "output measure." For the OMB94 submittal, this field will contain the CI. Although there are issues to resolve, HQUSACE intends to consider CI's in the decision-making process. Current HQUSACE concerns about CIs include (a) the fact that existing guidance is vague; and (b) the fact that CI's are applicable to work *items,* not work *functions*. Since work items receive CI ratings and work functions are processed by the ABS, it is necessary to derive a composite condition index (CCI) or to separate the work function into its individual items of work each having its own CI. The CCI will be a function of all corresponding work item CI's. It is unclear how the composite CCI will be derived from its child CI's. Current possibilities include taking the high or low CI, taking an arithmetic mean of all CI's, or taking a weighted mean of each CI. The weighted mean CCI is probably the most accurate and viable, provided that an engineering analysis is performed to assign weights to each CI category. An interim solution may be found in concurrent research, which is seeking to develop a "summary" CI based on professional expert judgement.

Port to oracle

The mainframe ABS currently resides on an IBM computer at the WCC. The database queries are done using RAMIS II. Update routines are written in COBOL with imbedded calls to the RAMIS II database management system. Reports and ad hoc queries are written in the RAMIS II native language.

The U.S. Army Engineer Waterways Experiment Station has ported the RAMIS II queries from the IBM clone to ORACLE on a CDC computer. This port takes advantage of the CEAP-backbone capabilities (e.g., high-speed access, etc.) and complies with the 1995 Corps Corporate Information Architecture. Currently, the COBOL routines are being converted to access the ORACLE relational database management system. It is envisioned that the port will be tested and completed by midspring 1992.

Bibliography

ABS Manual - No. I (District)

ABS Manual - No. II (Division)

Circular No. 11-2-157, 31 March 1990. Annual Program and Budget Request for Civil Works Activities, Corps, FY 1992.

Circular No. 11-8-2, 31 March 1991. Submission Requirements.

Langowski, J.F., and T.D. Feather, 1991. The Management Decision Environment of the Corps O&M Program. Report. Institute for Water Resources, U.S. Army Corps of Engineers, Fort Belvoir, VA.

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13. ABSTRACT *(Maximum 200 words)*

This report describes the development, testing, and evaluation of the Corps of Engineers Operation and Management Budget Decision Support System (COMB_DSS) developed under the Improvement of Operations and Management Techniques (IOMT) Research Program. This decision support application was designed to assist the Operations, Construction and Readiness (OCR) Division, Headquarters, U.S. Army Corps of Engineers (HQUSACE), with analysis of yearly Operations and Maintenance (O&M) budget submittals by the Corps Divisions. The report discusses the budget process for O&M project funding, the analysis needs of management at HQUSACE, a detailed description of general decision support system design, and the prototype design for assisting in the decision making process at HQUSACE. Decision support systems are computer-based information systems that typically contain four components: a database for storing large volumes of descriptive data, a user interface such as menus for information management, an analysis component for performing operations on the data, and report generation capability. The COMB_DSS contains five analysis capabilities for assisting in the O&M budget preparation: a scenario analyst, a financial analyst, a rank generator, a criteria analyst, and a statistical analyst. The testing and evaluation of the COMB_DSS at HQUSACE during the budget formation process is described along with recommendations for future improvements.

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