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ATTENTION OF

June 24, 1994

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MEMORANDUM FOR COMMANDER, Defense Technical Information Center,
Cameron Station, Alexandria, VA 22314

SUBJECT: Transmittal of IWR Report 93-R-18

1. Reference AR 70-31.
2. Two copies of IWR Report 93-R-18, "Corps of Engineers Operations & Maintenance Budget Decision Support System (COMB_DSS) Improvements Durnig the FY 95 Budget Process", has hereby been submitted
3. Initial distribution of this report has been made to appropriate Corps of Engineers agencies. It is recommended that copies of this report be forwarded to the National Technical Information Center.
4. Request for the DTIC Form 50 (Incl 2) be completed and returned to WRSC-IWR.

FOR THE DIRECTOR:

Kyle E. Schilling
Director

Enclosure

REPORT DOCUMENTATION PAGE

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13. ABSTRACT (Maximum 200 words)

The Corps of Engineers Operation and Maintenance Budget Decision Support (COMB_DSS) is a computerized tool for management, analysis and display of budget data submitted as part of the Corps' O&M program. The COMB_DSS facilitates the examination of a myriad of budget scenarios and aids in the selection of a final budget. This report documents the improvements made to the COMB_DSS during the FY 95 budget process. These improvements included routine "bug" fixes to the prototype COMB_DSS used during the FY 94 budget process, an enhanced and more intuitive menu system, and tuning of processing modules to improve the response of the system.

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**CORPS OF ENGINEERS OPERATIONS AND MAINTENANCE
BUDGET DECISION SUPPORT SYSTEM (COMB_DSS)
IMPROVEMENTS DURING THE FY 95 BUDGET PROCESS**

LETTER REPORT

by

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7701 Telegraph Road
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IWR Report 93-R-18

PREFACE

Decision Support Systems (DSS) are combinations of computer hardware and software designed to assist decision-makers in making complex decisions. DSS extend the capabilities of management information systems (MIS) primarily by providing additional analytical capability for examining the impacts of alternative decisions. This report documents a continuing research effort which began under the Improved Operation Management Techniques (IOMT) Research Program and has been continued through support of CECW-OM. The current effort, documented herein, served to modify, upgrade, maintain, and support the Corps of Engineers Operations and Management Budget Decision Support System (COMB_DSS) in the FY 95 budget cycle. The COMB_DSS, as it was used in the 95 budget cycle, is an extension of the COMB_DSS prototype previously developed for the Operations, Construction, and Readiness (OCR) Division to support the FY 94 budget.

This research project was a team effort. Two pivotal members of the team are Dave Harmon and Dennis Kern (CECW-OM). Dave Harmon is the primary user of the original prototype COMB_DSS used by HQUSACE in the FY 94 budget submittal and spent many hours helping the research team develop and improve the system. Dave is also the primary author of the Division ABS software system, which is used by Division personnel to rank and submit the annual Operations and Maintenance Budget. Michael R. Walsh, CECW-IWR-R, was the project technical monitor and provided the project team invaluable support, technical guidance, and advanced testing. Planning and Management Consultants, Limited (PMCL) provided technical support under contract to the Institute for Water Resources (IWR.) Craig A. Strus was PMCL's project manager and provided technical support to the project team. Russ E. Robinson (PMCL) developed the data import and export mechanisms and performed system testing. Richard M. Males, RMM Technical Services, Inc., a subcontractor to PMCL, was intensely involved in this work effort and performed the majority of system modifications required for the FY 95 budget cycle.

This report was written by Craig A. Strus, Richard M. Males, and Michael R. Walsh. Comments about this report are encouraged and should be directed to Michael R. Walsh, CEWRC-IWR, Casey Building, Fort Belvoir, VA 22060 (703) 355-3087.

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I. INTRODUCTION

OVERVIEW OF REPORT

The organization of this report, in addition to the preceding preface, is as follows. This chapter provides an overview of the research events leading up to this work effort and discusses the research objectives. Chapter II discusses, in more detail, previous efforts leading up to current COMB_DSS system. Chapter III discusses, in detail, system changes made in this work effort. Chapter IV summarizes the work effort, providing design team insights on system strengths, weaknesses, and future directions of DSS tools in the Corps O&M Arena.

BACKGROUND AND EVOLUTION

The Corps of Engineers Operation and Management Budget Decision Support System (COMB_DSS) was originally developed as part of the Improvement of Operations and Management Techniques (IOMT) research program. The objective of the IOMT program is to (1) reduce costs while increasing the safety and efficiency of operations and maintenance management, (2) enhance the utility of O&M assets such as locks, dams, and vessels, and (3) address the economic and budgetary issues in the O&M function. The COMB_DSS was envisioned as a demonstration project oriented towards providing decision support capabilities for the existing O&M budget development process, at the HQ level, specifically to provide assistance in financial analysis and development of rankings for the work functions of the annual budget submittals.

The COMB_DSS was developed for HQUSACE as a prototype system and was written in R:Base 3.x/4.0, a relational database management system and product of Microrim, Inc. R:Base was chosen because of its rapid prototyping capabilities and adherence to ANSI SQL (Structured Query Language) standards. The prototype system actually used in the 1994 budget submittal. Because the COMB_DSS was successful, IOMT funded a prototype Division decision support system (COMB_DSS-D) to provide similar capabilities at the Division level. The COMB_DSS_D was similarly developed and used in conjunction with ORD's development of the 1995 budget submittal. The design team used the COMB_DSS as the starting point for the COMB_DSS-D, a recently completed work effort. Additional enhancements made to the Division prototype (COMB_DSS-D) in that work effort were folded into the COMB_DSS improvements in this work effort.

The COMB_DSS is a separate system, operating upon information from the Automated Budget System's (ABS) Corps-wide budget database. Within the ABS, Districts and Divisions generate and rank work function packages. The completed ABS database eventually resides under Oracle on a CDC computer in Vicksburg, MS. The ABS supports the submittal of annual budget information for review and appropriation at the District, Division, and Headquarters levels. Information is transferred from the ABS database to the COMB_DSS database. Analysis of the budget is then performed within the COMB_DSS including work function prioritization and ranking. Information is then passed back to the ABS. Thus, the ABS works as the primary data-

gathering and correction system at the District and Division level, and the COMB_DSS is specialized for analysis and ranking functions. It is intended that, over time, the decision support systems of the COMB_DSS be folded into enhanced ABS capabilities in a single system.

PROJECT OBJECTIVES

The project objectives were to: (1) perform bug fixes uncovered during system application in the FY 94 budget cycle, (2) provide a more intuitive and enhanced menu system, (3) enhance system capabilities to better support the budget submittal process at the Headquarters level, and (4) provide system support, as required, to Headquarters personnel.

II. COMB_DSS BACKGROUND

CONCEPTUAL OVERVIEW

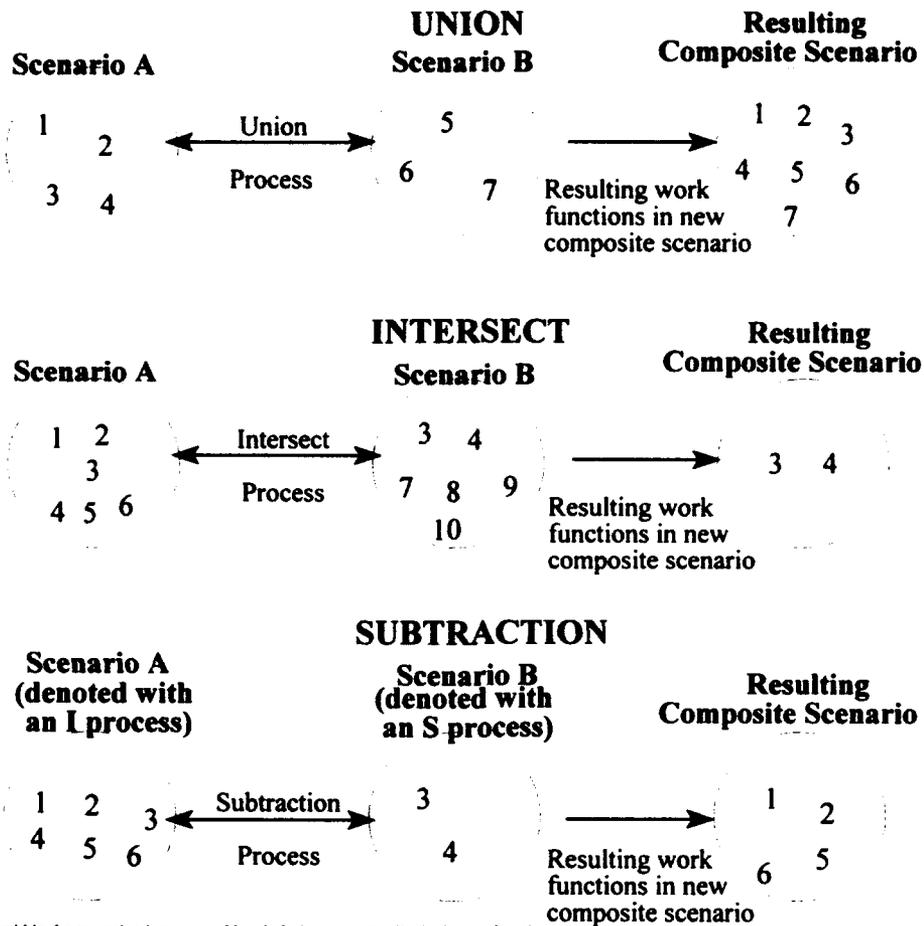
During the evolution of the first COMB_DSS prototype, the concept of a *scenario* was developed. A scenario can be considered a subset of work functions containing a likeness (e.g., a set of work functions from the same Division or a set of work functions with the same feature cost code). The COMB_DSS prototype allowed the user to build, modify, and delete scenarios, thereby providing a means for managing 'groups' of work functions. Additionally, by storing scenarios, a finite audit trail of analysis events is created. The COMB_DSS-D contains three types of scenarios: *Primary*, *Composite*, and *SQL*.

Primary scenarios were designed as the basic method of grouping work functions together for future reference, reporting, and financial analysis. A two page data entry form was developed to allow primary scenario selection criteria to be entered and edited. The first field in the primary scenario screen insists that a unique scenario name be assigned. Some of the constraints, applied to work functions in the creation of a primary scenario, are as follows:

- Appropriation (e.g., E, F, or C) REQUIRED
- Low use navigation flag
- A range of OCE (Bogus) ranks
- A range of output measures (really condition index)
- Two user defined variable ranges (used in ranking)
- A minimum cost on the work function
- A cumulative cost, above which (or below which) no more work functions are obtained for the scenario
- Whether or not the cumulative cost should be calculated in ascending or descending order.
- Constrain to particular Division code(s).
- Constrain to particular Class(es) of work.
- Includes and excludes of particular CWIS numbers, OCE ranks, and Feature Cost Codes.

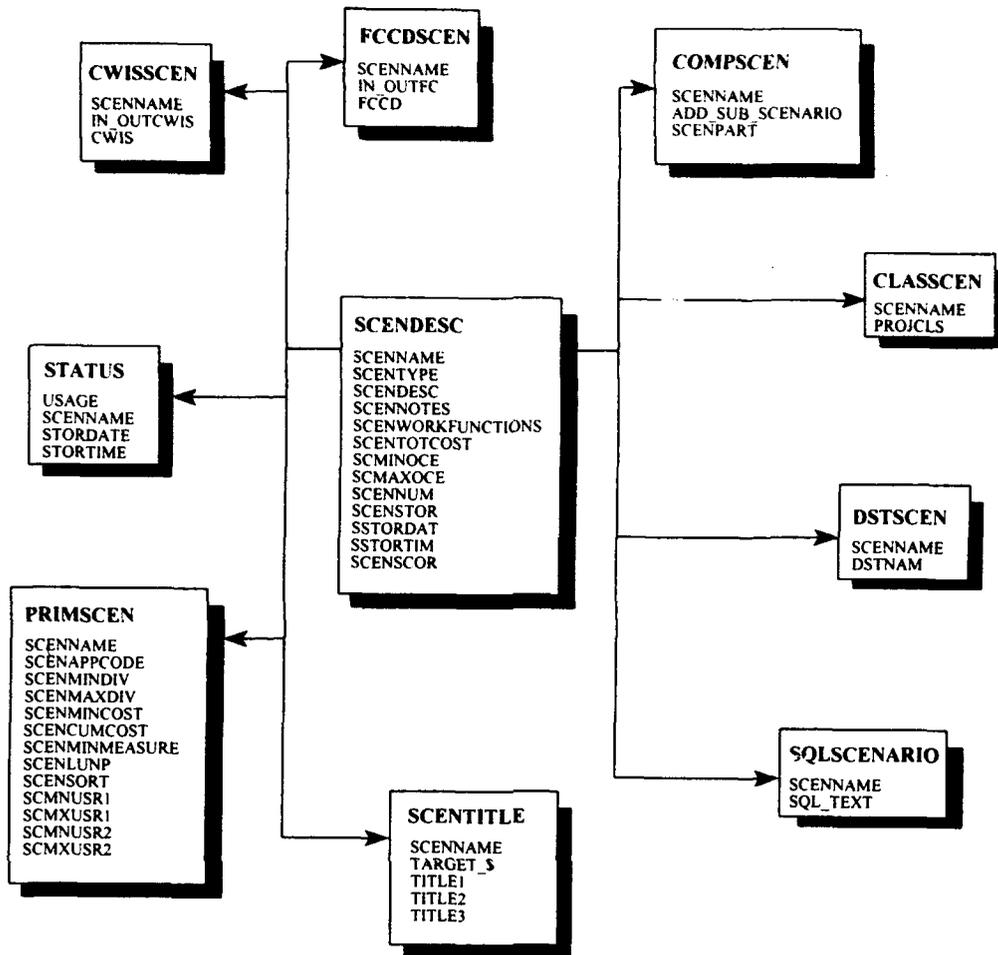
A 'composite' scenario is an integration of primary, composite, or SQL scenarios, built through an 'intersect', 'union', or 'subtraction' process. A Union (U) scenario process will provide the union of work functions contained in each scenario labeled as U (i.e., any work function in any U process is in the composite.) An intersect I scenario process gives the intersection of work functions contained in each scenario labeled as I (i.e., the work function must be present in all I work functions to be included in the composite.) The S scenario process subtracts work functions in the S scenario processes from the work functions in the I scenario processes. The S process cannot be combined with the U process, only with I processes. Note that I and U processes are also mutually exclusive. When S and I are processed jointly, the I scenario processes are handled

first, and then the S scenario processes are subtracted. Scenario Composite scenario processes are detailed in Figure II-1.



Note: The numbers within the scenarios (represented by circles) represent individual work functions

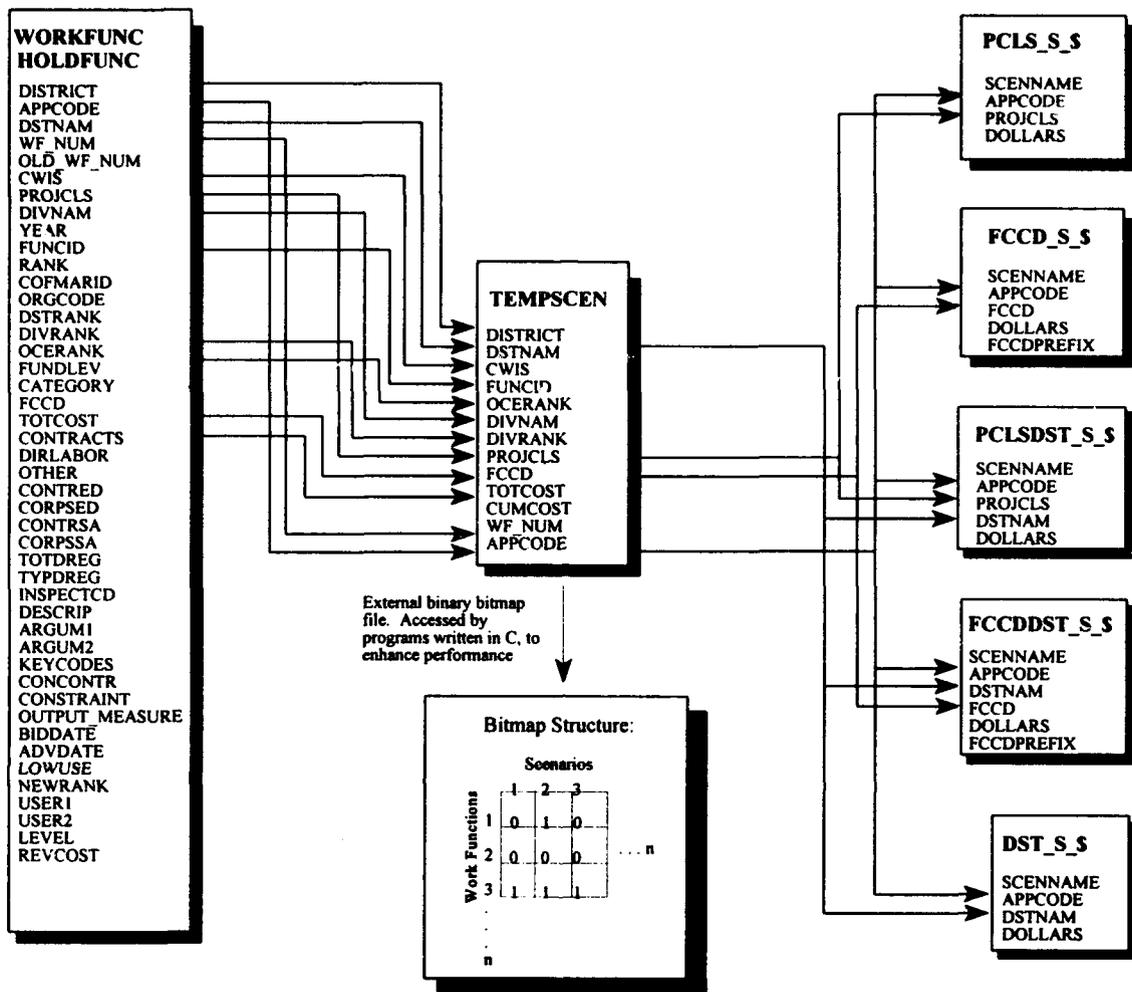
FIGURE II-1
SAMPLE COMPOSITE SCENARIO PROCESSES



**FIGURE II-2
SCENARIO TABLES**

The COMB_DSS-D also contains an 'SQL' (pronounced 'see-quel') scenario capability, which enables the user to build an ad-hoc scenario with consideration of selection criteria that are not available through the primary scenario data entry forms. The user can enter an SQL *where* clause, which generates a constraint on any field or combination of fields in the table containing available work functions. Once created, an SQL scenario can be joined with primary or composite scenarios through the union, intersection, or subtraction processes discussed and depicted previously. The tables used to store all three types of scenario information for retrieval at a later time and the relationships between them are depicted in Figure II-2.

Note that when a scenario is run, the results (the set of work functions that satisfy the selection criteria for the scenario) are stored in the TEMPSCEN table. After a scenario is evaluated, it can be permanently 'stored' in a work function-scenario matrix file stored outside of R:Base and cost summaries are saved in five summary tables shown on the right of Figure II-3.



**FIGURE II-3
SCENARIO STORAGE TO ROLLUP TABLES**

The concept of *scoring* was also introduced in the original COMB_DSS prototype. The scoring capability allowed the COMB_DSS user to assign a score to a scenario. In this process, each work function for a given scenario is assigned the scenario's score. Because a work function may be in more than one scenario (overlapping scenarios), the lowest score (1 is better than 2) is assigned to the work function. The entire set of work functions are then 'dumped', by division, score (ascending), and division rank (ascending) to an ASCII file. This file is then read by a custom program which, for a given score and division, creates a stack containing descending Division ranks. These Division stacks are then placed into a single, common stack, with each Division chosen randomly, to arrive at a final OCE rank that preserves, in as much as possible, the Division rank (i.e., the original Division rank is only disturbed by the inclusion of the score). The scenario/scoring approach is not possible under the use of previous HQUSACE tools, and its advent into the budget process has saved the Corps money in terms of time and resources.

HQUSACE PROTOTYPE

The original IOMT work effort focussed on the development of decision support tools to better support the annual budget submittal process. A system concept was developed and was followed by multiple software 'prototypes', in which a prototype was built, reviewed by Headquarters personnel, and modified based upon the review. This process is termed rapid application development (RAD), or iterative prototyping, in which a system is built, reviewed, and modified to better serve the client needs, after a relatively brief design phase.

In August of 1992, the COMB_DSS prototype was applied to the FY 1994 budget. Once the Division analysis was complete, the Division databases were aggregated into a Corps-wide database, which served as the starting point for Headquarters analysis. A number of problems were uncovered in the Corps-wide database, which were resolved with the COMB_DSS prototype's quality assurance data checks. Following database corrections, the actual analysis began.

To ensure that the system operated as intended, personnel from the design team provided on-site support. As the analysis process evolved, a number of system bugs were uncovered and corrected. Additionally, a number of rollup reports were written to provide information that was not 'on menu' (built) into the system. In retrospect, the on-site support proved invaluable as: (1) the system would not have been successful otherwise, and (2) it was shown that system modifications could be made in a short period of time.

DIVISION PROTOTYPE

A follow up research effort was funded by IOMT to explore the potential for DSS in the budget process at the Division level. The design team saw the COMB_DSS prototype as the starting point for Division analysis and felt that the system could be modified to support Division requirements. The Ohio River Division (ORD) was selected as a test-bed for implementation, and an initial meeting took place in March 1993. The meeting involved a discussion of system requirements, which were broken into five primary components, as follows:

- (1) Quality Assurance - checks on the District data
- (2) Scenario Analysis - financial summaries of the data
- (3) Division Ranking - development of the Division ranks
- (4) Impact Analysis - determination of impacts of HQ and OMB decisions
- (5) Data Transfers - data input and output to/from ABS format files

In the development of iterative prototypes, each of the five components were evolved to meet Division needs. All of the COMB_DSS capabilities were retained for the Division prototype, but only a subset of them were actually used in the budget submittal process.

The ranking procedure used in the HQ version of COMB_DSS was demonstrated to Division personnel, but did not meet ORD ranking requirements. The HQ ranking method operates at an aggregate level, ranking scenarios, as discussed in the previous section. ORD, with fewer work functions to handle, and a determination to permit Districts to develop their own rankings in so far as possible, set 'cutoff' ranks, below which District rankings were accepted automatically. ORD then examines and ranks each work function from level 2 through waivers. This was done in

a two-day group meeting at which representatives of the Districts were present. Computer support was necessary to capture the assigned ranks developed during this meeting, and to display the financial consequences (allocation of dollars by District, within funding level), of the ranking. Accordingly, an entire set of routines to provide 'real-time' support for the ranking process was developed for the COMB_DSS-D prototype.

Division personnel indicated that, upon development of scenarios and the use of financial analysis to assess those scenarios, work functions would need to be re-ranked, starting at a different rank level for each District, appropriation code, and FCCD group (O&M). This has been accomplished 'manually' in the past, by comparison, prioritization, and integration of work functions from District paper piles into a single Division paper pile. This new Division paper pile was then assigned new Division ranks based upon the meeting participants' decisions. To serve the Division needs, the design team modified the COMB_DSS-D work function table, including a field called 'newrank'. Once the newrank field was in place, an additional table was built into the COMB_DSS-D prototype that allowed the Division to edit the starting rank for each District by appropriation. Thus, by providing different starting ranks for each District, appropriation code, and FCCD group (O&M), the ranking of all work functions up to a certain cutoff (e.g., level 1) was automated.

III. SYSTEM MODIFICATIONS

OVERVIEW

This work effort was funded by CECW-OM to enhance and maintain the COMB_DSS prototype system used in the FY 94 budget cycle. The design team coordinated closely with system users to ensure that the list of system changes were comprehensive and could be accomplished in the designated project time frame. Following the '94 budget submission, a list of desired changes and enhancements was developed by the project team in April of 1993, prior to full implementation of the Division COMB_DSS-D. Certain enhancements to the Division system were then carried forward to the modified Headquarters system. A second meeting to review work to date was held in early July of 1993. Additional modifications were made based on this meeting, and the modified system was delivered in mid-July of 1993. A discussion of the 'punch-list', additional system enhancements, and a summary of on-site support follows.

MODIFICATION LIST

The following modification list is broken into logical components, which were created towards the end of the development of the original COMB_DSS prototype, and was modified at an initial meeting between system users and design team personnel. All items in the modification list were accomplished. Text found in italics provides additional information on specific system changes where necessary.

Menu Structure

- Revise menu structure as pulldowns (Lotus Style) from a horizontal menu:

This was accomplished by incorporating the enhancements made to the COMB_DSS-D menu structures into the COMB_DSS prototype system with minor modifications.

- Re-organize menus such that commonly used functions are available where needed (e.g., list a file)
- Create and run scenario at same menu level.

This was accomplished by modifying the menu system.

- Move reconstruct scenario to scenario management and execution.

Scenario Management

- Ensure unique scenario names across scenario types, not just within a scenario type.

This is the case, which is enforced by an R:Base rule.

- Do not allow deletion of a scenario that is part of composite.
- Ensure that changing a scenario name does not allow the user to assign one which already exists.
- Insure that all parts of the create, delete and edit scenario process are operating correctly.
- Provide a routine which updates all scenarios that are affected by changes in other scenarios. (At issue with composite scenarios).

This is a complex process. A detailed memo was prepared to explain the issues relating to scenario dependencies, and methods of updating scenarios.

- Extended clone scenario capability, which allows creation of SQL scenarios specific to each Division, based upon a master existing SQL scenario. Thus, a 'Clone SQL For Divisions' button should exist, which changes the scenario name automatically and adds 'divnam = "xxx"' for each Division. The user would be prompted for the first five characters of the scenario name, and the Division suffix would be added automatically to the scenario name and the description field.
- Develop the capacity for SQL scenarios to allow matching another table with a prompt that includes a 'from' clause, as well as a 'where' clause.

The entered SQL clause is now parsed by the program, to determine if a 'from' clause exists, and handled accordingly. The user must be aware of the possibility of creating queries that take a long time to process.

- Develop a utility on the menu that will list the scenarios (name, number and type) associated with a specific work function.

An additional C-language program to process the bitmap file to obtain all scenarios for a given work function was created. A report, including the scenario name and description, is generated to a file, and then displayed on the screen.

- Develop a procedure, within financial analysis, to load the default column headings and default totals in, prompt for title editing, then generate the report, as opposed to the current two-step process of running the analysis first, then editing and re-running.

Reports

- Fix the problem with sub-totals not adding up properly in Division summary reports.
- Add the scenario name for each column as a footer at the bottom of each Financial Analysis report.
- Check District subtotals on the division-feature cost code Financial Analysis report. District subtotals do not agree with other reports.
- Many of the reports were added during the budget analysis process and are not integrated properly into the menu structure. Organize all reports and place them within the menu structure.

Bug Fixes

- Fix the problem with 'set extended on', which appears to be associated with the inputs/outputs of the crosstab process, which reset extended to off.

Ranking

- Develop an 'all-in-one' one-button re-ranking option.

Tools

- Provide a scenario dependency report for a single chosen scenario.
- Provide is a diagram of all the command files used in the system showing their relationships to the menu, and to their internal hierarchy.

Data Transfers

- Develop transparent data transfer approaches, using command files rather than Gateway.

Procedures were developed using a combination of R:Base SQL commands and Clipper routines. The Clipper routines served to resolve R:Base naming conflicts.

ON-SITE SUPPORT

On-site support in this budget process was minimal because (1) the analysis time frame was somewhat expanded, (2) Headquarters personnel used the system in the previous budget cycle and are technically capable of performing system changes when necessary, and (3) system modifications leading up to the analysis provided users with an enhanced decision support tool. Design team personnel from CECW-IWR-R provided the majority of on-site support with additional phone support occurring as required.

SYSTEM UPGRADE

During the analysis process, Dave Harmon moved the system from R:Base version 4.0a to R:Base version 4.5 (a significant package upgrade from the vendor). In this conversion, a number of problems were encountered and resolved (in italics) as follows:

- CONSTRAINT field in the WORKFUNC table is a now a reserved word and must be changed.

Changed CONSTRAINT to CONSTRANT, where found in system tables. Also modified the import and export procedures to operate on the revised field name.

- EDIT/ENTER SQL Scenarios are no longer working properly.

A dummy table was used in the form to hold a flag indicating whether or not the SQL scenario should be tested for validity. This table was removed and replaced with a variable field which performs the same test.

- The crosstab statements in SCENREP7.CMD had to be modified. FCCDPREF was changed to FCCDPREFIX.

This process involved changing the name of an internal table. R:Base 4.5 recognizes unique table names up to 32 characters, as opposed to 8 characters in previous versions.

IV. SUMMARY

OVERVIEW

This current work effort was executed successfully, as indicated by minimum on-site support required by the design team. It should be noted, however, that the COMB_DSS is an advanced learning tool and requires a significant learning curve. As it turns out, Headquarters are very technically proficient users and because of their involvement in the development of the product, required little training. As the Headquarters system continues to evolve, changes will be required and can be implemented by members of the design team. Additional training will likely be required if personnel changes are made at the Headquarters level.

OTHER CONSIDERATIONS

The Operations and Maintenance (O&M) budget is under review by an O&M Task Force and a number of changes are envisioned in the next budget cycle, as follows:

- Baseline work function ranks will fall between 10,000 - 19,999 and will include dredging and non-dredging projects.
- Non-deferrable project ranks will fall between 20,000 - 29,999 and will adhere to a set of justifying rules, including new requirements or mandated.
- Deferrable project ranks will fall between 30,000 - 39,999 and will include special interest items.
- Addition and Betterment (Improvement) ranks will fall between 40,000 - 49,999.
- Maintenance and Repair ranks will fall between 50,000 - 59,999 and will include those work functions where are beyond the Corp's funding ability.
- Feature cost codes will be reduced from 86 to 64.
- Sub-feature cost codes will be reduced from 241 to 177.

Although some of the changes detailed above will have implications on the COMB_DSS, all are properly aligned with the scenario concept and the management of work function groups. However, additional requirements may be placed on the budget process which cause a significant effect on the way the COMB_DSS handles and analyzes data. This can only be determined when the new budget guidance is finalized, which may require an additional budget cycle to implement in the COMB_DSS.

NEXT STEPS

Headquarters has requested that the COMB_DSS-D prototype applied at ORD be used to handle the Division ABS procedures in the FY 96 budget cycle (Calendar year 1994). That is, the COMB_DSS-D will be used, with modification, in place of the Division ABS. The design team feels that the capabilities made available to ORD in the COMB_DSS-D prototype can be extended to make the system, through training, a Corps-wide system. A distributed Division system will require field interviews and a demonstration of the existing prototype, which will serve as the basis for a concept document. From the concept document, iterative software prototypes will be developed and documented, with the final prototype slated for training and implementation as the first-cut distributed system.

The District ABS is currently being ported to Microsoft Access (a windows-based relational database management system) with a Visual Basic (also a product of Microsoft) windows-based front-end (interface). The port is being performed by Construction Engineering Research Laboratory (CERL) under the guidance of personnel from CECW-OM. The system is currently in design phase, and is slated for implementation in the 1997 budget cycle (calendar year 1995). At that time, or potentially concurrently, a windows-based design will be considered for the COMB_DSS and the COMB_DSS-D. The desire, in the long-term, is to arrive at an integrated system, in which the COMB_DSS and the ABS operate as a single unit, with differences, as required, across levels.