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Review and Evaluation of the SARA System for Application to the Corps of Engineers Project Management Function

by
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This study explored the capabilities and limitations of the SARA System as a project delivery system, investigated the applicability of SARA to the Corps of Engineers life-cycle project management operation and function, and identified appropriate applications of the SARA System to the Corps' project-management activities. It is concluded that full integration of this technology will allow the Corps of Engineers to more efficiently and effectively respond to the needs of planners, engineers, constructors, operators, and ultimately, the disposers of the facility, without increased staffing.

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FOREWORD

This research was performed for Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Funding Acquisition Document (FAD) No. 90-080003, dated October 1989, "SARA Evaluation." The HQUSACE technical monitor was Mr. John Sheehey III, CEMP-P.

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USACERL). The USACERL principal investigator was Mr. Donald Hicks. Mr. Glenn Rasmussen was associate investigator. Special acknowledgement is given to Mr. Robert Neathammer, team leader of the Real Property Management Team, for assisting with the development and supervising the progress of the project. Dr. Michael O'Connor is Chief, USACERL-FS. The USACERL technical editor was Mr. William J. Wolfe, Information Management Office.

COL Daniel Waldo, Jr. is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

There are many automated processes with sophisticated capabilities for design, specification, cost estimating, construction planning, scheduling, post-occupancy evaluation, and maintenance resource prediction. However, since many of these systems have been independently developed for particular disciplines or phases, they have never before been integrated into a complete, coordinated, and integrated project management system.

The entire design and project management process is accomplished by several groups, working independently, using different and uncoordinated databases, each of which uses computer-aided techniques and systems to simplify its work and to assure accuracy and completeness. Information is usually transferred between groups on paper, if at all. The Corps of Engineers, which acts as the project/construction management agent for other organizations, transfers much information between agencies in this way. Consequently, the record of the decisionmaking process is often discontinuous and sometimes irrecoverable.

Recent advances in the processing and storage capacities of the personal computer (PC) have made programs and databases previously considered to be mainframe applications widely available. These technological advances have facilitated the development of complex programs that can coordinate complex processes of management. The SARA Project Delivery System is one such program that may help to integrate the parts of the Corps of Engineers' facilities acquisition process, and to maintain a complete records archive, from design to disposal. Appendix A shows a flowchart diagram of the SARA Project Management System.

Objective

The objective of this investigation was to determine if the SARA System could support the Corps of Engineers' facilities acquisition process, either totally or in part.

Approach

The SARA Systems was reviewed and its capabilities were compared to the demands of the Corps of Engineers' facilities acquisition process. The SARA System was demonstrated using Corps of Engineers' design and construction data. Corps of Engineers' Field Operating Agencies (FOAs) (hands-on users) were invited to evaluate and critique the SARA System and its application to Corps procedures.

Scope

This report is limited to the review and evaluation of the SARA System for project management. It is believed that, at this time, the SARA System is the only program of its kind offering a fully integrated, interactive professional design and management tool designed to assist the professional user in all phases of project management. This investigation was limited to evaluating SARA's adaptability to Corps of Engineers procedures.

Mode of Technology Transfer

The results of this investigation will be forwarded to the Headquarters of the U.S. Army Corps of Engineers (HQUSACE) for further action.

2 PROJECT DELIVERY OVERVIEW

The SARA system automatically develops a complete project analysis based on as few parameters as geographic location, bid date, and population to be served. As the project matures and specific project information becomes available, new data is entered into the SARA modules (Program, Estimate, Footprint, Schedule, and Track), which enable the program to estimate, schedule, and track data as it is updated.

The Project Delivery capability of the SARA system can be used for new construction, renovations, modeling and forecasting. The system user may access any module at any time to achieve any desired level of detail. The system user may also override the project data developed by SARA to more closely match the specific requirements of a particular project.

SARA provides the system user with solutions, never a blank spreadsheet, at every point of the facility development stage. The solutions provided by SARA reflect those building factors typically applied to facilities of similar type and function constructed across the United States. This is accomplished using a compilation of carefully gathered data from construction projects administered by facility professionals over the last 25 years. By allowing SARA to perform the time-consuming calculations while applying expert rules during the project development stages, facility professionals can more effectively use their professional expertise.

SARA performs facility development functions through an "inference engine"; therefore, the system actually "learns" as a facility develops. As data is entered into a module, SARA automatically impacts and updates the project data contained in all of the other system modules to develop a comprehensive facility program. SARA is divided into five interactive modules: Program, Footprint, Estimate, Schedule and Track.

Program Module

SARA's Program module will automatically assemble a complete facility, including space requirements, room relationships, room sizes, and cost information, using the appropriate Control Estimate Generator (CEG) standards and guidelines. SARA develops both assignable and nonassignable spaces from which an accurate net-to-gross ratio and building footprint can be generated. The system uses historical cost databases to develop a cost by room for the facility, the cost for moveable equipment, the occupancy and the quality of the facility. The program net-to-gross and cost is therefore representative of both the actual facility being developed and the historic quality and unique requirements for the facility.

Footprint Module

The SARA Footprint module automatically produces facility definitions and space relationships using the standards and guidelines developed from the CEG or program data. This becomes a very useful tool in facility programming, since it provides the facility programming professional with an optimized footprint of the facility under evaluation, based on the appropriate codes, standards, guidelines, and other requirements. Through a graphic interface, the programmer can quickly and accurately define a facility to the most stringent requirements (Appendix B). The facility definition information is produced in both tabular and graphic formats that reflect the space relationships, structural requirements, egress requirements, and many other requirements developed from the CEG system.

Estimate Module

The Estimate Module automatically performs the first order engineering cost analysis from which a comprehensive detailed cost estimate is ultimately produced. The SARA system develops each of the building systems required to construct the facility. The detailed cost estimate includes the individual task descriptions, along with quantities and totals that are subdivided into equipment, labor, and materials in the Computer Aided Cost Engineering System (CACES) Crew Composition Database and the CACES Labor and Equipment Database. A detailed cost estimate can be developed to reflect the facility program, engineered and design parameters, facility systems, and/or a quantity takeoff. The engineered cost analysis provides the ideal mechanism for value engineering. Different building systems can be rapidly evaluated for their impact on facility cost, project delivery time and project budget cash flow. When the USACERL-developed Maintenance Resource Prediction Model (MRPM)[1] is linked with the SARA System, a Life Cycle Cost Analysis (LCCA), in terms of operations and maintenance (O&M) cost projections, can be generated. The impact of design and engineering decisions can be immediately analyzed and evaluated, both in terms of the immediate construction cost and the long-range O&M cost. SARA also provides the means for evaluating contractor-proposed alternates and change orders often associated with a project.

Schedule Module

The Schedule module automatically develops a complete day-by-day, task-by-task project schedule for the project, based on the facility detailed cost estimate generated by the SARA Estimate module. The project schedule is based on a dynamic calendar developed by the system to include each of the activities assembled in the detailed cost estimate, and will encompass the total time required from concept to occupancy. The project schedule can encompass all related project activities including design, site, and construction. Alternates and change orders can be rapidly addressed and their impact on the schedule evaluated. It is also possible to evaluate the impact of different systems on the project schedule, thus providing the value engineering process not only a cost analysis, but also a time analysis related to the ultimate completion date.

Track Module

The Track module serves as an information source for calculating the anticipated cash flow and as a management tool to monitor the project budget and schedule. A schedule of values is created, which includes all of the tasks from the detailed cost estimate. Each task is assigned the appropriate percentage of the project budget. Each percentage is calculated as the amount of equipment, labor and materials required to accomplish that task as it relates to the total contract amount. The scheduled percent complete for any date can be determined as well as the projected amount of the pay request for that date. This makes it possible to produce an accurate month-by-month cash flow report, which is produced in both tabular and graphic formats. Contractor-proposed alternates and change orders can be rapidly addressed and their impact on the schedule evaluated. When a project is monitored on a regular basis, the potential for the facility to be completed "on budget" and "on time" is significantly increased.

CACES/CEG Integration

When the extensive databases developed for the CACES and CEG systems are incorporated into the SARA System, they produce a unified and enhanced project-analysis system. The project-analysis methodology executed by the Corps of Engineers is parallel to that of SARA; therefore the merge of data and software between CACES and the Project Delivery System is mutually beneficial to both organizations.

The following information will explain in precise detail the steps that have been executed to show the capability to integrate the SARA System with the Corps of Engineers databases and cost engineering methodologies.

The objective of the software integration evaluation is to outline the incorporation procedure of the CACES information with the SARA System. The following tasks are included in the evaluation and have been closely examined by SARA Systems, Inc.

1. Evaluate the potential for integrating the CACES National Price Book Database into the SARA System to produce Quantity Takeoff Detailed Estimates.

2. Evaluate the potential for integrating the CACES Crew Composition Database into the SARA System to produce Dynamically Defined Crews and Task Durations. This will be evaluated in reference to integration with the SARA Scheduling module and Resource Evaluation. In addition, the Dynamically Defined Crew, based on the CACES Crew Composition Database and resulting Task Durations, will be evaluated for integration with the CACES National Price Book Database to produce detailed labor and equipment costs.

3. Evaluate the potential for integrating the CACES Labor and Equipment Database with the Dynamically Defined Crews and the Detailed Quantity Takeoff, based on the CACES National Price Book Database. The result would be to determine if sufficient labor categories and equipment categories presently exist within the CACES Labor and Equipment Database, or if additional categories will be required to reasonably produce labor and equipment costs and resource leveling in the Scheduling module.

4. Evaluate the potential for integration of the Detailed Quantity Takeoff Estimate produced by integration of the CACES National Price Book Database, CACES Crew Composition Database, and the CACES Labor and Equipment Database with the SARA Scheduling module and the investigation of the application of the SARA automated scheduling techniques.

5. Evaluate the potential for integration of the CEG information into the SARA Programming module and investigate the application of SARA's automated facility definition and layout procedures to the facilities defined with the CEG.

6. Evaluate the potential for integration of the CEG facilities defined by the SARA Program module with the Detailed Estimate module to produce Detailed Quantity Takeoff Estimates from Engineered Parameters based on the facility program. Understand the impact of this capacity on the process of Value Engineering and Life Cycle Cost Analysis in terms of O&M cost using the Maintenance Resource Prediction Model.

7. Evaluate the potential for integration of the SARA System's Engineered Parameters module with the CACES Database-Driven Detail Quantity Takeoff System.

8. Evaluate the potential for integrating the SARA System's Footprint module with the CEG information to permit input relating to facility definition.

9. Evaluate the potential for integrating of the SARA System's Tracking Module with the CACES and CEG Database-Driven Project Delivery System.

3 EVALUATIONS

Evaluation of Item 1

Evaluate the potential for integrating the CACES National Price Book Database into the SARA System to produce Quantity Takeoff Detailed Estimates.

Summation

A complete integration between the CACES National Price Book and the SARA Project Delivery System was proven successful by the SARA Professional Evaluation Team. The specific goal of this evaluation was to determine the feasibility of matching the CACES information to the SARA format. The current data format of the CACES information has been modified to match the SARA format. This standardized format is a crucial element within SARA due to an extensive menu scheme rigidly followed by each of the SARA modules.

Methodology

The CACES National Price Book contains the informational equivalent of the SARA Task Database, where each system is based on the Construction Specification Index (CSI) format. Both informational databases contain specific data related to construction building materials, from which an ultimate cost analysis can be developed.

SARA is designed as a windows environment format, using a large number of pop-up windows and pull-down menus. The selection of data through the use of pull-down menus is the primary element the CACES information must routinely follow.

SARA uses short descriptions with maximum line lengths of 60 characters. This results in a precise and detailed description. The system user can then very rapidly review the detailed descriptions and select the option that most closely matches the specific project requirements.

The SARA menus operate using a hierarchical menu format. The first-level hierarchical menu contains a broad description, encompassing numerous related options.

The second-level menu contains a more detailed breakdown. Notice that as each successive level is accessed, the system leaves a clear highlighted path back to the first information searched.

When the final-level menu is displayed, the user selects the option that most precisely matches the requirements of the project. The CACES information has been transformed to match the SARA hierarchical menu format.

CACES Format

The primary difference between the two materials databases is the format in which the information is displayed. The format display of such information is a critical component of integration between the two systems.

Both systems use the Construction Specification Index (CSI) hierarchical materials format. Each successive level yields more detailed information. The CACES interpretation of the CSI materials implements a seven-level hierarchy, where each individual level displays an abstract description. The facility professional must develop a mental or tabular summation, which is formulated from each of the seven individual abstract descriptions, to achieve a comprehensive final description of the construction material.

For example, a proposed facility requires a 38-pair Telephone Cable No. 22 AWG (American Wire Gauge), installed on poles aerially, which falls within CSI category 16 - Electrical. The CACES National Price Book contains 181 pages of materials related to electrical materials.

Step 1: Using the CACES National Price Book, the facility professional must first locate the first major CSI category of Division 16 Electrical on page 576. This appears in the form of a bold heading at the upper left hand corner of each page.

Step 2: The second-level categories related to electrical must be closely reviewed. "16050 Basic Materials and Methods" is the second-level category located on page 576. Second-level categories are displayed as bold and listed once on each page just below the column headings.

Step 3: At the third-level CSI category, each category must be carefully reviewed for the "16120 Wire and Cable" category. "16120 Wire and Cable" is found half-way down page 604 on the page designated 16114 Cable Trays. The levels are continuous and are not marked by page breaks. Third-level categories are indented and not bold, and appear as a sub-heading under the second-level CSI category on each page where the materials in that category occur.

Step 4: The fourth-level CSI category, "5000 Telephone Cable No. 22 AWG" is searched and found on page 611. Fourth-level categories are indented and shown only once as a heading to the category if all materials at that level appear on the same page. If the materials span more than one page, the heading will appear again at the beginning of the next page in the level four position. There is no message "continued" to distinguish initial from continued headings.

Step 5: The fifth-level CSI category, "5300 Installed on Poles, Aerially," is listed halfway down page 611, indented from the surrounding list, but not bold. A category at this level split by a page break will repeat the fifth-level category heading on the next page. Indication that the category is continued is through item numbers.

Step 6: At the sixth-level CSI category, the optional item materials may be selected from a menu.

Step 7: At the seventh and final CSI category, 2133 22 Ga. is selected on page 611.

Step 8: At this point, the facility professional/cost engineer is required to sum each of the CSI codes and descriptions, using a number of lines of information, to produce a final definition equivalent to 38-pair, Telephone Cable No. 22 AWG, installed on poles aerially:

(level 1) **Division 16—Electrical**
(level 2) **16050—Basic Materials and Methods**
(level 3) **16120—Wire and Cable**
(level 4) **5000—Telephone Cable NO. 22 AWG**
(level 5) **5300—Installed on Poles Aerially**
(level 6) **5310—Alternative Materials**
(level 7) **5313—38 Pair**

Such a complicated procedure, for each material included in a detailed cost estimate, can become cumbersome. Many times, the facility professional/cost engineer must refer back to the page headings to remain directed. Any time a line needs cross-checking, the process slows and there is chance for error. Setting all necessary information on a single line which can be viewed easily at a glance for each material item speeds up access, and decreases error ratios. The SARA System already uses the single line detail and CACES easily integrates to that format.

Integration

The objective is to provide a transparent interface to the Micro-CACES (M-CACES)[2] estimate and the National Price Book, to take advantage of the strengths, while maintaining the features and individuality, of both databases.

The user interface to the National Price Book is located in the *add* submenu of *Task and Report* options in the Estimate module. The "Database" selection makes it possible to select either the SARA or the National Price Book database for task selection.

To interface at the technical level with the National Price Book, several issues have been addressed:

1. Indexing
2. Line Item Descriptions
3. Crew
4. Labor
5. Equipment.

The first action when selecting a National Price Book version for the first time is for the system to recognize and build a "hashed" index, or a method of directly referencing records in a database by doing algorithmic transformations on the search key. The result is an address or pointer that provides rapid and random access into the database.

There are many ways to turn a search key into a table address. SARA translates the character-based search key into a unique number. This number is then divided by a large prime number, and the modulous (remainder) is accessed as the table address. For example, the key AKEY would be changed to 44217. By using the prime number 107, the key AKEY "hashes" to position 80 in the table. Position 80 in the table has a corresponding address in the database file. Ideally, different search keys should map to different addresses, but occasionally two or more search keys will hash to the same table address. To overcome this collision, chaining is used to connect all colliding search keys to the table address.

For instance, the key CHAIN is represented by the value 61892 and also hashes to position 80 in the table. The corresponding address in the table position 80 is 1239. By looking at the record pointed to by 1239, it can be seen that this is not the correct record. By using the chain pointer that is included in the table location and chaining to another table location, another pointer to the database file can be found. This method of chaining is used until the correct record is found.

All M-CACES databases accessed by SARA use a hashed index. This provides a slightly larger code module, but the overall performance is greatly enhanced.

The second issue addressed to make the National Price Book function in a menu-driven computer based system was to modify the individual task item descriptions. This modification provides the end user a clear, concise, one-line description of a task presented in a menu format. However, to maintain the integrity of the National Price Book in its present dBASE format, these individual line-item descriptions are kept in a separate database. Access to the National Price Book is then obtained by the CSI cross reference using the hash table built for the National Price Book. An individual task record is then retrieved from the National Price Book for access to crew codes, equipment, performance, etc. This information provides the basis for building an estimate record. Existing M-CACES estimates are then accessed and integrated for use with SARA System's modules. The first step is for the system to integrate the M-CACES estimate into the SARA System. Each record in the M-CACES estimate is read and mapped to the SARA System's Estimate module. This is done in a manner transparent to the user. Existing M-CACES estimates simply appear as projects within the SARA project menu. The integration can use the existing estimated costs or the estimate can be recalculated to take advantage of the dynamic crew configuration capabilities of the SARA System.

To allow for a complete integration of the CACES information with the SARA Task Database, and for the database to function as a SARA menu, the format of the CACES information required modification. The CACES seven-level descriptions were closely reviewed by the SARA Professional Evaluation Team to develop a unified, final CSI-level, 60-character description. The Professional Evaluation Team has determined that by developing the 60-character descriptions for the CACES materials database, the system user can quickly scroll though a final CSI-level menu to select the comprehensive description that best matches the project requirements.

The modified CACES materials database continues to implement a seven-level CSI hierarchical format, but using a detailed 60-character description for each item. The first level displays a broad description, and each successive level provides more detailed information.

The integration process of the seven-level CSI format of the CACES National Price Book Database required the SARA Professional Evaluation Team to first closely review each CACES material description. As each description was evaluated, the evaluation team then elaborated upon the CACES definition to produce a modified 60-character string description of each item. The new 60-character string description in each of the seven CSI levels allows the system user to receive a full description of each material item in the CACES National Price Book Database.

To produce each of the CACES 60-character descriptions, the evaluation team first referenced the hard copy CACES National Price Book manual to develop the first level of CSI categories. Each subsequent level within the major CSI category was evaluated. Using the hard copy modifications, a data entry person then typed each of the unified 60-character descriptions in ASCII format. These ASCII CSI material descriptions are stored within a database, and are automatically accessed as a menu during the development of a detailed cost estimate using the SARA Estimate module.

SARA provides a "search" mechanism to help the user automatically find specific information. The search can be performed hierarchically, beginning at the most general level and successively moving toward the most precise. The search function also operates using a "keyword."

The system user is required to type a brief character description of the material and the system will search the database for all entries containing the keyword(s), retrieving all equivalent options. The selections will appear in the window as the CSI third-level selections.

For example, if 22-gauge, 4-in. ribbed, steel roof panels (1 in. = 25.4 mm) are to be included in a detailed cost estimate, the following set of steps would be executed using the modified CACES information.

CSI hierarchical format:

Step 1: Using the modified CACES information, the system user selects "7 Thermal and Moisture Protection."

Step 2: The second-level categories related to thermal and moisture protection appear and can be searched until "07400 Preformed Roofing and Siding" is located.

Step 3: At the third-level CSI category, "07410N Roofing" is selected.

Step 4: At the fourth-level CSI category, "2000 Steel Roof Panels" is selected.

Step 5: At the fifth-level CSI category, "2100 Steel Roof Panels for Structural Steel Framing. Fasteners Included" is selected.

Step 6: At the sixth-level CSI category, "2130 4 In. Rib. Painted" is selected.

Step 7: At the seventh level, the detailed informational descriptions are displayed. The system user must review each description and select the option most closely matching the project requirements. The seven sequenced selections can be recommended as follows:

(level 1) 7 Thermal and Moisture Protection
(level 2) 07400 Preformed Roofing and Siding
(level 3) 07410N Roofing
(level 4) 2000 Steel Roof Panels
(level 5) 2100 Steel Roof Panels for Structural Steel Framing, Fasteners Included
(level 6) 2130 4 In.Rib.Painted
(level 7) 2132 Str Stl Pnl 4-in. Rib PaintedStr. StlFraming 20 Ga
2133 Str Stl Pnl 4-in. Rib PaintedStr.StlFraming 22 ga.

Step 8: Once the detailed description is selected, SARA requires the unit quantity of steel roof panels, 4-in. ribbed, 22 gauge by unit.

Step 9: The scheduled zone is required for selection. The selected task information is processed and calculated by the system and added to the detailed cost estimate.

Keyword Method

Step 1: The system user types a brief character description of the building material of interest.

Step 2: SARA searches the CACES materials and displays the 6th-level options related to steel roof panels. The system user selects the 6th-level description.

(level 6) 21304 IN. RIB. PAINTED

Step 3: The final CSI-level descriptions appear for review and selection:

(level 7) 2132 Steel roof panels, 4-in. ribbed, 20 ga.; 2133 Steel roof panels, 4-in. ribbed, 22 ga.

Step 4: Once the detailed description is selected, SARA requires the unit quantity of steel roof panels, 4-in. ribbed, 22 ga. by unit.

Step 5: The scheduled zone is required for selection. The selected task information is processed and calculated by the system and added to the detailed cost estimate.

The SARA menu selection format makes the entire selection process much more efficient. The key to such an automated process is the implementation of menus and material definitions that accurately and precisely define each unique material.

Generation of the Detailed Cost Estimate

The modified CACES information, when incorporated into the SARA task selection process, facilitates the generation of a detailed cost estimate (Appendix C). While developing a detailed cost estimate, the SARA Estimate module automatically includes the amount of materials and also dynamically configures a crew, consisting of both labor and equipment. The performance levels of these crews and the material quantities are automatically passed into the SARA Schedule module to produce a comprehensive project schedule. The facility professional/cost engineer possesses the ability to easily modify the detailed cost estimate to more accurately reflect the unique characteristics of a specific project.

The detailed cost estimate can be generated by the SARA Estimate module using several methods, each of which accesses the modified CACES materials information.

Method 1: A comprehensive detailed cost estimate can be developed to reflect a facility program developed by the SARA Program module. The system automatically assembles each of the building materials, quantities, costs and crew configurations required to construct the programmed facility type.

Method 2: A detailed cost estimate can also be developed using the parametric method. The SARA Estimate module engineers each of the building systems associated with the design and function of the facility, where a building system represents a compiled group of construction materials. The detailed cost estimate is developed in a quantity takeoff format, producing a breakdown of construction materials, quantities, costs and crew configurations.

Method 3: The final method uses the quantity takeoff method. The facility professional/cost engineer extracts measurements and quantities from hard-line drawings. These quantities are then applied to the appropriate building materials, allowing the SARA Estimate module to calculate the associated costs and crew configurations.

During the development of a detailed cost estimate, the system automatically follows a five-step process.

Step 1: A construction material is selected either automatically by SARA or independently by the user.

Step 2: The system references the engineering parameters to determine the quantity of the material which will reflect the type, size, and function of the facility.

Step 3: The system dynamically configures a construction crew, which includes both labor and materials, to install the task quantity.

Step 4: A level of output is established for each crew configuration, which is based on national and/or local norms. Since both the material quantity and crew performance level is established for each task, a project schedule can be automatically generated by the SARA Schedule module to reflect the detailed cost estimate.

Step 5: The SARA Estimate module automatically generates the various cost reports related to the detailed cost estimate. This is done as a result of the established material costs, labor rates, and equipment rates stored in each of the applicable system databases. SARA does the calculations necessary to achieve a total cost report that can be sorted in many useful patterns. Figure 1 shows a typical detailed cost estimate report.

The detailed estimate spreadsheet contains specific information related to the individual project tasks. In addition to the information above, the spreadsheet also contains the following information:

- item number
- alternate number
- keyword
- sort preferences 1, 2, 3
- CSI reference
- unit equipment
- scheduled zone
- unit labor
- description
- unit material
- unit quantity
- unit equipment, labor and materials
- unit measurement
- equipment factor
- unit equipment, labor and materials
- labor factor

Item No.	CSI Ref	Sched Zone	Description quantity	Unit el&m	Unit el&m	Total
1	3	B3	AA concrete, foundation wall	160 CY	43.00	6880.00
2	3	B2	AA concrete column stem, foundation wall	48 CY	43.00	2064.00
17	3	B2	AA concrete, slab on grade, 4"	1564CY	43.00	67252.00
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					Total	xxxxx.xx

Figure 1. A typical detail cost estimate report.

- total equipment, labor and materials
- material factor
- total shifts
- adjusted unit equipment
- units/shift
- adjusted unit labor
- scheduling zone
- adjusted unit material
- number of crews
- adjusted unit equipment, labor and materials.

The preceding takeoff quantity format can be developed at the program, schematic, preliminary and final stages of a project using the SARA Estimate module. All of the information developed in the SARA Estimate module is automatically passed forward into the SARA Schedule and Track modules and used as the basis for a project schedule, schedule of values and cash flow analysis.

To accurately evaluate the performance of the SARA Estimate module using the CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to determine the accuracy and compatibly within the environment of the Corps of Engineers.

Evaluation of Item 2

Evaluate the potential for integrating the CACES Crew Composition Database into the SARA System to produce Dynamically Defined Crews and Task Durations. This will be evaluated in reference to integration with the SARA Scheduling module and Resource Evaluation. In addition, the Dynamically Defined Crew based on the CACES Crew Composition Database and resulting Task Durations will be evaluated for integration with the CACES National Price Book Database to produce detailed labor and equipment costs.

Summation

The CACES Crew Composition Database, together with the CACES National Price Book Database, has been fully integrated with the SARA System to produce detailed cost estimates. The CACES Crew Composition Database is an integral component of the CACES National Price Book Database when developing a complete project cost analysis. With both databases incorporated into the SARA System, the derived cost analysis will reflect the CACES material costs, labor rates, and equipment rates. The detailed cost estimate represents a comprehensive breakdown of materials subtotaled by equipment, labor, and materials.

Both the CACES Crew Composition Database and the SARA System use crew configurations to execute the performance of unique tasks. The CACES Crew Composition Database supplies a large number of permanently defined crews, while the SARA Estimate module supplies dynamically configured crews assembled by crew definition algorithms. When the CACES crew configurations are combined with SARA's dynamic crew definition algorithms, a unified and enhanced crew definition methodology is achieved.

CACES Methodology

The CACES Crew Composition Database is comprised of a large number of permanently defined crews and equipment combinations that are used to perform specific tasks. The crew composition will depend upon the type of task to be performed. The CACES National Price Book Database lists each material, a unit quantity, crew designation, crew daily output, unit man-hours, unit labor cost, unit equipment cost, unit material cost, total direct unit cost, and shipping weight. The CACES system cross-references the information between the CACES National Price Book Database and the CACES Crew Composition Database to perform the basic calculations associated with the production of a detailed cost estimate.

Often, the differences between the crew configurations will vary only by the productivity rates. The actual crew composition does not change.

Crew MSPFA (page 142)[3]

No.	Hours	Index	Craft/Equipment Name	Daily Cost
0.36	2.88	EMI20	Small Tools	3.74

Crew MSPFC (page 142)

No.	Hours	Index	Craft/Equipment Name	Daily Cost
0.72	5.76	EMI20	Small Tools	7.48

To closely review CACES crews MSPFA versus MSPFC, the prominent difference becomes a difference of productivity. By increasing the number of hours worked per day, the level of output/productivity is amplified.

SARA Methodology

The SARA Estimate module dynamically defines a crew for each construction task included in the detailed cost estimate. The crews are dynamically assembled by crew definition algorithms. SARA also dynamically assembles a crew composition for the placement of the materials included in a task. SARA first references the type and quantity of materials and then assembles the type and size of crew required to perform such activities. Such crew definition algorithms let SARA "learn" about a project. For example, when the placement of 200 yards of concrete is required on the second level of a facility, SARA will dynamically assemble the size and configuration of the crew to match the unique task. A crew configuration will include the unit quantity and unit cost of each type of labor and equipment. A crew configuration for this type of task may include:

No.	Rate	Description
6	22.02	Common building labors
1	28.68	Equipment operator, medium equipment
1	44.58	Crane and concrete pump
1	2.00	Concrete bucket 1 CY
1	18.56	Cement finisher
2	6.11	Gas engine vibrator

For each crew configuration, a daily performance level or level of output is automatically established. These performance levels are used by the SARA Schedule module to produce a daily or weekly schedule for the project. The system is flexible enough to adjust work schedules to accommodate union dictations, specific work regulations, or foreign national customs.

The SARA Schedule module uses the performance levels established for each crew to produce a complete task-by-task schedule for the proposed project. A duration is developed from each of the performance levels, thus allowing either a daily or weekly schedule to be produced. The length of time required to perform the work associated with the task is also apparent in the overall project cost.

Once the crew database is established, direct user interaction is not required. The crew database functions in the background during the development of a detailed cost estimate, the operations transparent to the user. Several crew databases may exist concurrently within the SARA System, allowing the user to select the particular crew rates based on the specific project requirements.

When a project schedule is automatically developed by the SARA Schedule module, the number of available human resources and equipment can be defined. Limiting the number of resources will eliminate overscheduling of finite resources. The overall project schedule will show the impact of resource limitations.

Integration

The CACES Crew Composition Database has been integrated into the SARA System's Estimate module as a subdatabase to the National Price Book. The first time the CACES Crew Composition Database is accessed, a hashed index is built. This provides rapid random access to each crew selection. The same format and structures as used with the National Price Book are used with the CACES Crew Composition Database for consistency and performance. The existing crew database contains hard price summaries for equipment and labor. Because the SARA System configures that crew dynamically, the actual labor and equipment rates are re-performed and the total labor and equipment costs are figured dynamically.

This also makes it possible to load labor or equipment rates specific to a project site and have the estimate reflect these rates, thus creating a basis for a National Price Book for every project site instead of only by region. This results in estimates that should be significantly more accurate.

The CACES system contains numerous static crew configurations with associated productivity levels. This information, when evaluated with the SARA crew configuration algorithms, generates dynamically configured crews, ultimately producing a precise cost analysis. The CACES Crew Composition Database is integrated with the SARA Estimate module through the use of additional algorithms that reflect the crew combinations compiled by the CACES system.

The CACES static crew combinations reflect a fixed project size and do not account for variables in size or complexity. In contrast, the SARA Estimate module dynamically assembles a crew to reflect variable size, complexity, location, productivity, and environmental impacts.

The integration process of the CACES Crew Composition Database with the SARA Estimate module required the SARA Professional Evaluation Team to closely examine each of the CACES predefined crew combinations and associated productivity. The evaluation data compiled from this process was then used to develop new and fine-tuned crew configuration algorithms, applying the CACES crew definition methodologies. Therefore, projects have crews dynamically configured to meet all variable facility elements.

Dynamic crew configurations effectively address each project variable to produce a crew of greatest efficiency and productivity. When human resources are limited in a particular trade, the dynamic crew configuration accommodates this finite resource and reflects the cost and schedule impacts. The dynamic crew configurations are used by the SARA Estimate module to derive an accurate cost analysis of each task. The cost and time information is passed automatically into the SARA Schedule module to produce a comprehensive day-by-day, task-by-task schedule for the proposed project.

To accurately evaluate the performance of the SARA Estimate module, using the CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to determine the accuracy and compatibility within the environment of the Corps of Engineers.

Evaluation of Item 3

Evaluate the potential for integration of the CACES Labor and Equipment Database with the Dynamically Defined Crews and the Detailed Quantity Takeoff based on the CACES National Price Book Database. The result would be to determine if sufficient labor categories and equipment categories presently exist within the CACES Labor and Equipment Database or if additional categories will be required to reasonably produce labor and equipment costs and resource leveling in the Scheduling module.

Summation

The CACES Labor and Equipment Database, together with the CACES National Price Book Database and CACES Crew Composition Database, has been fully integrated with the SARA System to produce comprehensive project costs. Each of the databases functions interactively, allowing the system to retrieve the applicable information from each database during the production of the cost analysis. An adequate number of available labor trades and equipment types are currently supplied by the CACES Labor and Equipment Database in order to produce accurate costs and resource leveling.

CACES Methodology

The CACES Labor and Equipment Database contains the informational equivalent of the SARA rate database. The database contains the various labor and equipment trades with associated rates per hour. During the development of a detailed cost estimate, the CACES National Price Book Database, the CACES Crew Composition Database, and the CACES Labor and Equipment Database are integrated to produce a cost analysis for a proposed project.

SARA Methodology

SARA follows a methodology parallel to that of the CACES format during the development of a project cost analysis. The final format of a cost analysis includes a breakdown of the individual materials that will comprise the construction of the facility, subdivided by equipment, labor, and materials. SARA derives the costs related to the labor trades and equipment types from the SARA rate database, which is stored within the system. This database contains detailed descriptions of the various labor trades and equipment types across the country. The detailed cost estimate can be generated by the SARA Estimate module using several methods, each of which accesses the modified CACES databases:

Method 1. A comprehensive detailed cost estimate can be developed to reflect a facility program developed by the SARA Program module. The system automatically assembles each of the building materials, quantities, costs and crew configurations required to construct the programmed facility type.

Method 2. A detailed cost estimate can also be developed using the parametric method. The SARA Estimate module engineers each of the building systems associated with the design and function of the facility, where a building system represents a compiled group of construction materials. The detailed cost estimate is developed in a quantity takeoff format, producing a breakdown of construction materials, quantities, costs, and crew configurations.

Method 3. This method uses the quantity takeoff method. The facility professional extracts measurements and quantities from hard-line drawings. These quantities are then applied to the appropriate building materials, allowing the SARA Estimate module to calculate the associated costs and crew configurations.

Method 4. Any of the dynamically configured crews and associated productivity levels can be reconfigured by the user. The impact of such crew/productivity reconfigurations can be immediately observed in the detailed cost estimate and the bar chart schedule.

During the development of a detailed cost estimate, the system automatically follows a six-step process:

Step 1: A construction material is selected from the materials database either automatically by SARA or independently by the user.

Step 2: The system references the engineering parameters to determine the quantities of materials, which will reflect the type, size and function of the facility. When following the quantity takeoff method, the system user is required to provide a unit quantity derived from hard-line drawings.

Step 3: The SARA crew configuration algorithms dynamically configure a construction crew, including both labor and equipment required to install the material quantities.

Step 4: A productivity level is automatically established, which reflects the crew configuration. Therefore, the SARA Schedule module can produce a complete project schedule based upon the number of units produced per day.

Step 5: The labor and equipment costs for the crew assembly are derived from the rate database, while the materials cost is derived from the materials database.

Step 6: The SARA Estimate module automatically generates the various cost reports related to the detailed cost estimate. This is accomplished as a result of the established material costs, labor rates, and equipment rates stored in each of the applicable system data-bases. SARA performs the calculations necessary to achieve a total cost report which can be sorted in numerous patterns desirable to the user.

Integration

The CACES labor and equipment databases have been integrated into the SARA Systems Estimate module as a subdatabase to the CACES Crew Composition Database. The first time the CACES labor and equipment databases are accessed, a hashed index is built. This provides rapid random access to each labor and equipment record. The

National Price Book format is used with the CACES Crew Composition Database for consistency and performance.

The dynamic definition of the crew size and performance requires rapid access to the Labor and Equipment Databases. Defining the Labor Database with the appropriate rates for a specific project results in very accurate estimated labor cost. The CACES Labor and Equipment Database has been easily automated for the SARA rate database during the generation of a cost analysis. The labor and equipment rates used by the CACES system to develop a detailed cost estimate are used in the calculation of a cost analysis. SARA references the CACES National Price Book Database, the CACES Crew Composition Database and the CACES Labor and Equipment Database to produce a cost for the performance of a construction task. The individual building materials are assembled, followed by the dynamic crew configuration required to install the materials. The crew labor and equipment rates are representative of the CACES databases.

The CACES Labor and Equipment Database has been automated for use by the SARA Estimate module. SARA evaluated each of the labor trades and equipment types defined by the CACES system to determine an adequate number of resource and equipment types. The labor and equipment database is maintained in ASCII format, allowing the system user access to update the hourly rates and modify the contents of the database as necessary.

The labor and equipment information not only includes the actual cost per hour but also provides a mechanism for resource leveling. For example, the number of available carpenters may be specified to prevent the SARA Schedule module from overscheduling a particular trade. Limitations on the number of available trades or equipment may result from union restrictions, strikes, or using in-house personnel with a limited supply of resources.

During the scheduling sequence, the SARA Schedule module can produce a daily or weekly schedule. As the schedule is produced, SARA references the rate database to determine the number of available resources and produces a calendar schedule that will span the duration of the project, including not only the construction phase but also the design phase. When the number of available resources is not specified, SARA will assume an infinite quantity is available. The facility professional/cost engineer also possesses the ability to modify the schedule to meet the unique requirements of the project. This modification is automatically reflected in the detailed cost estimate and cash flow analysis.

Once the labor and equipment database is established, additional trades and/or equipment, and modification of hourly rates can be included. Multiple-rate databases may also exist concurrently within the SARA System. The system user can then select the rates that most closely apply to the project specifications.

When a detailed cost estimate is developed using the SARA System, the following database equivalents are substituted:

CACES National Price Book Database
= SARA Task Database

CACES Crew Composition Database
= SARA Crew Database

CACES Labor and Equipment Database
= SARA Rate Database.

To accurately evaluate the performance of the SARA Estimate module using the CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to determine the accuracy and compatibility within the environment of the Corps of Engineers.

Evaluation of Item 4

Evaluate the potential for integration of the Detailed Quantity Takeoff Estimate produced by integration of the CACES National Price Book Database, CACES Crew Composition Database and the CACES Labor and Equipment Database with the SARA Scheduling module. Also evaluate the application of the SARA automated scheduling techniques.

Summation

A complete integration has been achieved between the SARA System and the CACES National Price Book Database, the CACES Crew Composition Database and the CACES Labor and Equipment Database. The three CACES cost analysis databases, fully integrated with the SARA System, produce an accurate cost analysis and project schedule.

The CACES National Price Book Database has been successfully integrated with the SARA System. The building materials contained in the CACES system are used by the SARA Estimate module to produce a quantity takeoff detailed cost estimate. The costs associated with each CACES building material are used during the calculation of the total materials cost analysis.

The crew configurations defined by the CACES Crew Composition Database are integrated with the SARA System to produce dynamically defined crews. As each construction task is added to a detailed cost estimate, the SARA Estimate module dynamically defines a crew to install such materials. The type and size of the crew configuration will depend upon the unique task requirements. The crew configurations are reflective of the CACES Crew Composition Database. Resource leveling is also achieved during the generation of the detailed cost estimate. SARA references the number of available resources and, during the production of the project schedule, the particular resource will not be overscheduled by the system, thus allowing effective finite resource allocation.

Each crew configuration is comprised of a series of labor trades and equipment types. To develop an accurate cost analysis, containing a cost breakdown of equipment and labor, the rate schedule stored within the CACES Labor and Equipment Database is applied. The individual construction trades, when configured as a crew, meet the requirements of the SARA System for both the generation of a detailed cost estimate and project schedule in which resource leveling is accomplished.

SARA Methodology

Once a detailed cost estimate is produced, the information is automatically cascaded into the SARA Estimate module to produce a complete project schedule.

Construction Schedule. A complete day-by-day, task-by-task bar-chart schedule of the proposed project is automatically generated by the SARA Schedule module. The project schedule is based on a dynamic calendar developed by the system to include each of the activities assembled by the SARA Estimate module. The schedule can include site and construction elements as well as design elements. For example, when the design phase elements are developed in the detailed cost estimate, this information is automatically scheduled into a bar chart format.

Each activity is automatically moved forward into the Schedule module, allowing the system to schedule a project ranging from very few tasks to thousands of tasks, depending on the size and complexity of the facility. The precedence sequence and duration of each task is automatically developed by SARA, which enables the user of the system to simply review and/or modify the information to meet the project requirements. Weather days, which reflect the weather patterns for the geographic location where the project is being defined, are automatically incorporated into the schedule.

SARA uses the critical path method (CPM) of scheduling, allowing several critical paths to exist concurrently during the life of the project. The bar chart schedules are printed on 8.5 x 11 sheets of paper for use during on-site project monitoring. The entire SARA bar chart scheduling sequence can be accomplished in less than 1 hour. Appendix C shows a sample output of a Facility CPM Schedule.

The SARA System can automatically establish both a comprehensive day-by-day and week-by-week bar chart schedule to meet the individual requirements of the user. The 1 hour required to produce a schedule that includes each of the individual activities assembled in the SARA Estimate module compares favorably to the several weeks required by hand scheduling. The SARA System saves significant amounts of time normally associated with the process of developing a CPM schedule because the system performs the laborious functions associated with generating a project schedule, such as creating the hard copy. Changes to durations or precedence can be accommodated by SARA easily and effectively. This assures a timely and accurate schedule and completion date at all points during the project development. The level of detail created in the schedule provides an opportunity to identify a digression from the schedule and the day it occurs. This allows the maximum time to adjust the schedule and determine any impact on the completion date. The data is produced on 8.5 x 11 sheets of paper, which is easily duplicated and updated to meet any schedule changes that occur throughout the life of the project. The project bar chart schedule information can be automatically passed forward into the SARA Track module and used as the basis for a schedule of values and cash flow analysis.

Graphic Precedence Flow Chart. SARA automatically generates the precedence sequence when the detailed cost estimate information is moved forward into the SARA Schedule module (See Appendix D.). The project schedule can include the site and construction elements as well as the design elements, which historically have not been included in a schedule. The user can modify the precedence of any task to meet the specific requirements of the project in only several minutes. When a task precedence or duration is modified, the detailed cost estimate information is immediately updated to reflect the change. The precedence flow chart is represented graphically and is printed on 8.5 x 11 sheets of paper.

Both time and money are saved because the precedence flow chart can be automatically developed by the SARA Schedule module in a matter of minutes. The flow chart is automatically produced in an 8.5 x 11-in. format, allowing the information to be reproduced and distributed rapidly. The project schedule information can be automatically passed forward into the SARA Track module and used as the basis for a schedule of values and cash flow analysis.

Date List Schedule. A complete date list schedule is automatically assembled by the SARA Schedule module. The date list can contain each of the site, construction and design elements compiled in the detailed cost estimate. The information is automatically moved forward into the Schedule module, thus producing a list of activities that are sorted by the date on which they are to commence, or by CSI code reference. The date list also contains the finish date, critical path indicator, and the total slack time associated with each task.

The date list is a tool the owner uses to observe specific tasks that must be performed on a particular date. For example, SARA provides the ability to sort all tasks related to the formation of interior walls. The system will produce a comprehensive list of dates on which all of the various interior wall placement activities will take place, thus providing better schedule management capabilities. In essence, the schedule is divided into "time windows." Once the interior stud placement is complete, the drywall appears next on the schedule. The entire process becomes a "snowball" or iterative effect. The tasks that fall within an individual contract can also be retrieved in a date list or CSI format. The owner can immediately see which of the tasks included in the date list fall on a critical path. The date list provides the actual dates on which tasks are to be performed. The date list project schedule information is automatically passed forward into the SARA Track module to be used as the basis for a schedule of values and cash flow analysis.

Integration

The integration of the CACES National Price Book, crew composition, labor, and equipment databases makes it possible to generate a detailed estimate using the SARA Systems Estimate module based on the CACES databases. In addition, an existing M-CACES estimate can be integrated into the SARA Estimate module. Due to this complete integration, the entire SARA facility knowledge base can be used to generate a detailed project schedule. Moreover, all of this will be transparent to the user, who will simply open an existing M-CACES estimate and then proceed directly to the Schedule module. No other action is required on the part of the user.

Once the schedule is created by the SARA System's Schedule module, the user has access to all of the features for adjusting and redefining the schedule. These include adjusting the precedence, and changing performance and crew size.

The integration of the CACES National Price Book Database and the SARA System required a review of the individual CACES building materials to develop a unified 60-character description for each line item. The 60-character descriptions can then function within the SARA hierarchical menu format. Only the task descriptions were modified; the cost and crew, etc. information relative to each material remain. When a detailed cost estimate is developed, the system user then accesses the CACES database of materials to produce an accurate cost analysis for a project.

The CACES Crew Composition Database contains an extensive list of crew combinations, which have been automated for the SARA System crew configuration algorithms, to produce a significantly enhanced database and software system. The CACES crew configurations have been automated in their present organizational format, thus enabling the SARA Estimate module access of the information. The CACES crew compositions contain the various labor trades and equipment types required to install specific material quantities. SARA uses the hourly rate of such trades and equipment defined by the CACES Labor and Equipment Database to calculate the cost of labor and materials in the detailed cost estimate. The present format of these costs are used during a project analysis performed for the Corps of Engineers. Projects developed by M-CACES using existing labor rates and crew configurations are automatically scheduled by the SARA Schedule module in their current format.

A comprehensive detailed cost estimate includes the individual task descriptions, supplied by the CACES National Price Book Database; crew configurations to install each material task, supplied by the CACES Crew Composition Database; and associated totals subdivided by equipment, labor, and material costs, supplied by the CACES Labor and Equipment Database and the CACES National Price Book Database. The cost analysis developed by SARA not only can include the construction elements, but can also incorporate the site and design costs associated with the project.

All of the tasks developed by the SARA Estimate module to be included in the detailed cost estimate are automatically passed forward into the SARA Schedule module, where a comprehensive project schedule is produced.

The SARA Schedule module automatically develops a complete day-by-day, task-by-task project schedule that reflects the detailed cost estimate. This is done by using the task durations established as each task crew is configured. The task durations are interpreted by the SARA Schedule module to produce a daily or weekly calendar schedule that includes each task and spans the duration of the project.

To accurately evaluate the performance of the SARA Estimate module, using the CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to do a direct comparison of the two systems, and to determine the accuracy and compatibility of SARA with the Corps of Engineers' environment.

Evaluation of Item 5

Evaluate the potential for integration of the CEG information into the SARA Programming module and investigate the application of SARA's automated facility definition and layout procedures to the acilities defined with the CEG.

Once each module has been defined, the facility programmer (the user) can select the major modules to be included in the facility and can access this information on a room-by-room basis. In addition, to summarize by major type, the Department of the Army guidelines were automated to make definition of the facility rapid and accurate. This was possible because the guidelines already have been broken down into major population categories as follows:

- Center for 60 Children
- Center for 99 Children
- Center for 120 Children
- Center for 144 Children
- Center for 198 Children

- Center for 244 Children
- Center for 303 Children.

The following standards were developed to automate the standards and guidelines already existing in the above format. These are presented to the programmer for review and modification prior to defining the facility.

Age Group:	6-18 mth	18m-3yr	3-5yr	6-12 yr
Staff/child ratio:	4/20	4/32	4/40	2/30
Group size:	10	16	20	30
Homebase/child:	45sf	25sf	15sf	0sf
Shared space/child:	22sf	8sf	4sf	6sf
Outside area/child:	50sf	75sf	100sf	220sf
Motor area/child:	0sf	6sf	8sf	6sf
Sensory area/child:	0sf	6sf	8sf	6sf
Group activities area/child:	0sf	0sf	8sf	8sf
Learning Center area/child:	0sf	0sf	0sf	8sf

Once the student-to-staff ratios are established, the administration area is automatically developed by the system. In addition, all ancillary spaces such as rest rooms, lavatories, closets, storage, etc. are developed by the system automatically. These standards provide the basis for the development of the facility program. There are innumerable other factors considered by the system based on its general knowledge of facilities. Because the system has a knowledge base of facilities already defined, it is possible to include additional or new facilities rapidly. It is not necessary to define all elements of a facility, only those unique to its development (Appendix B).

A detailed presentation of the integration of the child care center and its associated parameters is invaluable to the overall understanding of the systems analysis of the facility.

To accurately evaluate the performance of the SARA Program module using the CEG databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CEG system to determine the accuracy and compatibility within the environment of the Corps of Engineers.

Evaluation of Item 6

Evaluate the potential for integration of the CEG facilities defined by the SARA Program module with the Detailed Estimate module to produce Detailed Quantity Takeoff Estimates from Engineered Parameters based on the facility program. Understand the impact of this capacity on the process of Value Engineering and Life Cycle Cost Analysis in terms of O&M costs using the Maintenance Resource Prediction Model.

Summation

The facility program information developed by the SARA Program module, which incorporates the CEG program definition data, is automatically passed forward into the SARA Estimate module to produce a comprehensive detailed cost estimate. The development of a detailed cost estimate is accomplished by allowing SARA to automatically engineer the facility to reflect the facility program developed by the SARA Program module.

The cost analysis of the project is determined using the CACES databases. The detailed cost estimate includes each of the tasks required during the construction of the facility. These tasks are subdivided by equipment, labor, and materials to produce an overall project cost. The cost of equipment and labor in the detailed cost estimate is retrieved from the CACES Labor and Equipment Database, while the cost of materials is retrieved from the CACES National Price Book Database.

The actual steps involved during the production of a detailed cost estimate are precisely outlined in evaluation items 1 - 4.

SARA Methodology

A comprehensive detailed cost estimate is automatically developed by the SARA Estimate module to reflect a facility program developed in the SARA Program module. This is possible because the facility program contains precise information relative to the physical configurations of spaces within the facility. These space types dictate bay length, bay width, bay height, finishes, mechanical requirements, electrical requirements, egress requirements, and vertical and horizontal relationships. These specifications represent the basic design criteria for the facility. The engineering parameters encompass a comprehensive set of mechanical, electrical, civil, and structural engineering formulas, and code requirements. These formulas and codes are used to develop a quantity takeoff of all materials included in the construction of the facility. This information is automatically passed forward into the SARA Estimate module to develop a detailed cost estimate.

The SARA Estimate module executes a sequence of events required for the development of a detailed cost estimate. This sequence involves the definition of the following components: construction zones, engineering parameters, building systems, and cost quantity takeoff.

Construction Zones

The SARA Estimate module can develop the construction zones of the facility using two methods. The first method uses the space characteristics developed in the SARA Program module. SARA automatically compiles the zone configuration of the proposed facility based on the floor-to-ceiling heights, occupancy, mechanical systems, circulation requirements, and egress requirements developed during the programming phase. The construction zones are defined both vertically and horizontally to accommodate the functional relationships within the facility.

The second method allows the system user to define the construction zones manually. During the manual definition, the zones can be configured in both a vertical and horizontal format to meet the requirements of the facility. When either of the zone definition methods are executed, the macro scheduling sequence is also defined. The zone sequence is used by the SARA Schedule module to develop a comprehensive construction schedule.

The zone configuration can be defined very quickly at the early stages of the project development. The need for engineering consultants is reduced during this early stage due to the automatic generation of the construction zones. Since the zone definition can be performed rapidly, numerous zone configurations can be developed for use during the value engineering process. The construction zone information can be automatically passed forward into the SARA Schedule and Track modules and used as the basis for a project schedule, schedule of values and cash flow analysis.

Engineering Parameters

The engineered building parameters included in the SARA Estimate module can be developed using two methods. The first method uses the facility program data developed in the SARA Program module. The system will automatically produce a comprehensive set of engineering building parameters based on the facility footprint, building program, space characteristics, occupancy, location, and zones established in the program. By performing an engineering analysis, SARA will automatically perform the calculations necessary to produce a comprehensive list of engineered building parameters.

The second method of producing building parameters requires the system user to manually define the 10 basic parameters, including gross square feet, bay length and width, soil bearing capacity, etc. The system will then use the primary parameters established by the system user and expand the information to include approximately 200 various parameter types in only several minutes, based upon the engineering analysis.

When the SARA Estimate module automatically defines a comprehensive set of engineered building parameters, a significant amount of time and money is saved because SARA can perform an engineering analysis in several minutes instead of several days. In essence, SARA becomes the engineering and cost engineering consult at the early project development stages. SARA develops an extensive list of building parameters, requiring the system user simply to review each of the facility parameters. This feature facilitates the Value Engineering process. All of the information is contained in a single spreadsheet, which traditionally has not been available.

When the USACERL-developed Maintenance Resource Prediction Model (MRPM) is linked with the SARA System, a Life Cycle Cost Analysis (LCCA), in terms of operations and maintenance

(O&M) cost projections, can be generated. The impact of design and engineering decisions can be immediately analyzed and evaluated, both in terms of the immediate construction cost and the long range O&M cost. SARA also provides the means to evaluate contractor-proposed alternatives and change orders which are often associated with a project. The engineering parameters can be automatically passed forward into the SARA Schedule and Track modules to be used as the basis for a project schedule, schedule of values, and cash flow analysis.

Building Systems

The SARA Estimate module supplies two methods for establishing the building system types to assemble the proposed facility. The first method uses the building parameters previously engineered by SARA. When a specific building system type is selected for inclusion in the facility construction, SARA references the extensive list of building parameters to calculate the individual tasks included in the building system. For example, if a concrete column system is to be included in the construction phase, SARA will reference the number of columns, height of columns, number of pounds of reinforcement bar, cubic yards of concrete, contact areas of forms, etc. established as building parameters to calculate the individual tasks. Each task not only includes the quantities and types of materials, but equipment and labor as well. As the individual task line items are calculated, SARA accesses the parameters as well as wage rates to dynamically define the labor crews and establish a total estimated engineered cost. As the data is developed for each building system, the information appears in a single spreadsheet and includes each of the tasks assembled within the building system including equipment, labor, and materials.

The second method of the building system definition requires the architect to manually select the individual system types to assemble the facility. When either of the building system definition methods are used, SARA will automatically transport the tasks within the building systems into the takeoff quantity cost format. SARA then interactively maintains the building costs as the project develops, requiring only several minutes to update cost information.

The SARA Estimate module can rapidly produce an accurate building system analysis by detailed task prior to the production of hard-line drawings. There is little need for consultants at early stages because SARA automatically assembles all of the building systems necessary to develop a detailed cost estimate. Due to the speed in which the building systems can be developed and analyzed, multiple versions of the facility costs can be developed and compared. For example, the system user can change the size of columns and beams and SARA will immediately display the impact of modification in both cost and time formats. The information developed in the design phase can be automatically passed forward into the SARA Schedule and Track modules to be used as the basis for a project schedule, schedule of values, and cash flow analysis.

Cost Quantity Takeoff

The SARA System can either automatically develop the detailed quantity cost estimate or allow the facility professional/cost engineer to manually input material quantities into the SARA Estimate module. When a cost estimate is developed automatically, SARA will derive the information based on the facility program, zones, engineered parameters, and site data. This cost-estimate derivation can be performed solely from the project data existing within the SARA modules, or can be performed to reflect any new estimator modifications.

When a cost estimate is produced manually, the material quantities are directly entered into the SARA Estimate module to produce a final facility construction cost. The detailed cost estimate produced by SARA, using any of the costing methods, will ultimately produce cost information such as the level or zone in which the task exists, description, material quantity, total dollars of equipment, labor and materials, total number of shifts, crew configuration, and local labor and equipment rates. The construction crew is dynamically configured by SARA, which will result in actual performance levels and costs of the amount of equipment, labor, and materials required to accomplish an individual task.

The amount of time required to automatically produce a complete detailed cost estimate is significantly less than manual takeoff methods. A comprehensive estimate can be performed at the early project stage to determine the quality and cost of the facility prior to the production hard-line drawings.

Each cost estimate is unique because the system uses parameters engineered specifically for the facility using local labor and material price structures to develop an accurate facility cost. Fewer errors will result because the quantities developed by SARA are accurately defined from the engineered parameters, thereby eliminating mathematical and typographical errors. SARA allows the estimator to modify the cost estimate at any stage of the project development to reflect the unique requirements of the facility. The cost quantity takeoff can be automatically passed forward into the SARA Schedule and Track modules to be used as the basis for a project schedule, schedule of values, and cash flow analysis.

The final format of the detailed cost estimate can be presented in numerous arrangements including CSI, building systems, alternates, change orders, etc. The facility professional/cost engineer should closely review the detailed cost estimate to assure the data matches the specific project requirements.

Integration

The systems as defined in the CEG Library have some inherent deficiencies when integrated with a dynamically defined engineered facility analysis. Those systems have been analyzed and modified to function in the SARA Systems Estimate module. The following major issues were addressed:

1. The CEG systems are inconsistent in the breakdown of tasks. Some systems actually contain multiple systems within a single system:

05 INTERIOR OF CONSTRUCTION

051 INTERIOR PARTITIONS - FIXED

1000 METAL STUD 7 GYPSUM WALLBOARD

1001 METAL STUD PARTITIONS CONSIST OF DOUBLE LAYER OF STAGGERED 4IN METAL STUDS, 4IN METAL STUDS, 6IN METAL STUDS, 2-1/2IN METAL STUDS, 1-5/8IN METAL STUDS, 2IN SOUND ATTENUATION BLANKET, 7/8IN FURRING, 5/8IN GYPSUM WALLBOARD, 5/8IN TYPE 'X' GYPSUM WALLBOARD AND 5/8IN MOISTURE RESISTANT GYPSUM WALLBOARD, INCLUDED IN THE CARD(S) SHOWN IN TABLE 1. (Other systems will contain only a single line item.)

09 HEATING, VENTILATION & AIR CONDITIONING

092 HEATING SYSTEMS

1000 EQUIPMENT

1001 THE STEAM TO HEATING HOT WATER CONVERTER INCLUDED CARD(S): 15732 1105 STEAM CONVERTOR HVEA

2. Descriptions of the same system are inconsistent. Standardized descriptions have been developed to facilitate selection and clarity.

3. Systems contain multiple-size units. For instance, the masonry wall system will contain 4-in., 6-in., and 8-in. block. To work in a system format that is engineered for a specific facility, each of those items needs to be part of a uniquely definable system. The 4-in. block will have significantly different mortar and other requirements than the 8-in. block.

4. The systems have been assembled based on relatively small facilities. The largest facility type size is a three-story barrack. Most are one-story buildings. The systems in general do not address large multi-story facilities. In addition, each task in each system has been given a formula that is dynamically defined by the engineering analysis part of the Estimate module.

The enhanced systems in the CEG library, integrated with the engineered analysis information, produce accurate cost data for all of the Corps facility types presently in the CEG and new ones as they are defined. The integration of the CEG library makes it possible to use the CACES National Price Book, crew composition, labor, and equipment databases with all of the over 700 facility types defined in SARA Systems.

A complete detailed cost estimate is developed by the SARA Estimate module, which is reflective of the facility program developed by the SARA Program module. This is accomplished by the full integration and interaction between the SARA Program and Estimate modules. Data must be entered into the system only once, and the information will automatically cascade into all of the other system modules allowing SARA to develop the applicable data in each module.

Due to the complete interactive nature of SARA, the CEG program definition data, which is now integrated with the SARA Program module, is automatically and immediately integrated with the SARA Estimate module. Therefore, no additional efforts are required for a complete unification of the CEG system and the SARA Project Delivery System.

To evaluate the accuracy of the generation of an automatic detailed cost estimate, which is reflective of the facility program, the CEG database has been integrated with the SARA Program module and the SARA Estimate module. To accurately evaluate the performance of the SARA Program module using the CEG databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CEG system to compare the two systems and to determine the accuracy and compatibility within the environment of the Corps of Engineers.

Evaluation of Item 7

Evaluate the potential for integration of the SARA Systems Engineered Parameters module with the CACES Database Driven Detail Quantity Takeoff System.

Table 1

Included Cards

4	09260	1005	5/8 IN GWB 'X'	GWSF	4001
4	09260	1005			*4001
4	09535	1005	2 IN SAB	GWSF	
4	09110	1104	4 IN METAL STUDS	GWSF	
4	09110	1104	STAGGERED DBL L	AY	R
4	09110	1104	4 IN METAL STUDS	GWSF	
4	09110	1105	6 IN METAL STUDS	GWSF	
4	09110	1102	2-1/2 IN MET ST	GWSF	
4	09110	1222	1-5/8 IN MET ST	GWSF	
4	09110	1211	7/8 IN FURRING	GWSF	
4	09260	1003	5/8 IN GWBGWSF	0.00	
4	09260	1003	5/8 IN GWB MR	GWSF	4001
4	09260	1003			

Summation

A detailed cost estimate is generated by the SARA Estimate module to reflect a set of engineering parameters. The engineering parameters encompass a comprehensive set of mechanical, electrical, civil and structural engineering formulas, and code requirements. These formulas and codes are used to develop the quantity takeoff of all tasks included in the construction of the facility. The individual material costs, crew configurations, and labor and equipment rates associated with each of the tasks are being developed using the appropriate CACES databases, including the CACES National Price Book Database, the CACES Crew Composition Database and the CACES Labor and Equipment Database.

SARA Methodology

When an independent detailed cost estimate is developed, often during the schematic or 30 percent design completion stage, a set of engineering parameters are established from which a detailed cost estimate is produced. The engineering parameters represent a comprehensive set of mechanical, electrical, civil and structural engineering formulas, and code requirements. These basic engineering design parameters exist as a subset of the overall 200 various engineering parameters supplied by the SARA Engineered Parameters module.

The 200 individual engineering parameters can be defined using several methods. The first method requires the facility professional/cost engineer to manually define the first 10 critical parameters. SARA then automatically calculates the remaining 190 engineering parameters to reflect the definition of the first 10. When the calculation process is complete, the facility professional/cost engineer can then review the definitions and make modifications as necessary.

The second method requires the system user to manually define all 200 engineering parameters. The engineering parameters are then used to calculate the material quantities included in the construction of the facility. The material quantities are automatically passed into the SARA Estimate module, which will produce a detailed cost estimate.

Integration

The SARA Estimate module has been fully integrated with each of the CACES databases, including the CACES National Price Book Database, the CACES Crew Composition Database, and the CACES Labor and Equipment Database to produce a detailed cost estimate that reflects a comprehensive set of building parameters. When each task is developed in the detailed cost estimate, the material costs, labor rates, and equipment costs associated with the task are retrieved from the appropriate CACES database.

The 200 engineering parameters were reviewed to determine if the existing parameters should be expanded to accommodate the unique characteristics of facilities produced by the Corps of Engineers. This information was developed by design and facility management professionals knowledgeable in the specific fields. The engineering parameters currently encompass the specific algorithms, codes, and engineering formulas required by Corps of Engineers' projects.

The SARA Estimate module contains building systems used during a facility's construction. The building systems range from footings and foundations to mechanical, electrical, and specialty systems. Each system is comprised of a group of building materials which, when assembled, produce a complete building system. The CEG assembly database contains similar building systems. For example, a static wall system is defined and becomes an element from which the facility is constructed. The CEG building systems, integrated with the SARA Estimate module, produce additional construction systems from which a facility can be erected.

To accurately evaluate the performance of the SARA Estimate module using the CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to compare the two systems and to determine the accuracy and compatibility of SARA with the Corps of Engineers' environment.

Evaluation of Item 8

Evaluate the potential for integration of the SARA footprint capability with the CEG information to permit graphic input relating to facility definition.

Summation

The integration of the CEG system with the SARA Program module automatically produces facility definitions and space relationships using the standards and guidelines developed from the CEG data. This becomes a very useful tool in facility programming, providing the facility programming professional with an optimized footprint of the facility under evaluation based on the appropriate codes, standards, guidelines, and other requirements. By using the graphic interface, the programmer can quickly and accurately define a facility to the most stringent requirements. The facility definition information is produced in both tabular and graphic formats that reflect the space relationships, structural requirements, egress requirements, and other requirements developed from the CEG system. Because all program modelling is done in three dimensions, it is also possible to have the system display the massing of the facility and its integrated parts.

The SARA Program module supplies the capability of using a predefined graphic of the facility footprint and reversing the algorithms to produce a program based on the standards developed from the CEG data. The system user possesses the ability to manipulate and re-arrange the graphic space layout to more accurately reflect the project requirements.

Either graphic definition process produces a facility program from which a comprehensive detailed cost estimate, schedule, schedule of values, and cash flow is developed using the CEG and CACES databases.

SARA Methodology

The SARA Program module automatically generates a complete facility program and layout, including space requirements, room relationships, and room sizes based on historical facility information, standards, and guidelines. The functional requirements of the proposed facility are interactively entered into the SARA Program module to produce a facility program, budget, and schedule. SARA develops a net-to-gross ratio from which a facility cost is developed.

SARA transforms the facility program definition into a graphic format allowing the physical space relationships to be observed. The system user can manipulate the graphic layout by rearranging the physical layout, resizing the rooms, and by adding and deleting rooms. The layout modifications automatically impact the tabular facility definition.

The facility program layout information is automatically cascaded in the SARA Estimate, Schedule and Track modules to produce a comprehensive detailed cost estimate, schedule, schedule of values and cash flow analysis.

Integration

The integration of the CEG system with the SARA Program module automatically integrates the graphic layout capability of the SARA System. Because the CEG includes both standards and guidelines for the program and the detailed requirements for the building system, it is possible for the system to also develop the basic layout of most engineering systems.

For instance, the mechanical duct work is automatically designed and the layout completed by the system. Each room receives the appropriate number of registers and grilles and the associated duct work. This duct work is connected back to a main feeder, and from there back to the mechanical equipment room. This automation of the engineering design effort, and complete integration with the programming effort, make it possible to define at the earliest possible point any conflicts in space, function, or engineering systems with the facility under consideration.

The integration with the footprint module results from the integration of the CEG with all other modules of SARA Systems. The footprint module best illustrates that the design process is recursive and nonlinear. As each element of the facility is developed from program, through engineered estimate, to schedule and tracking, each builds both forward and backward on the others.

As each room has its space and function defined, it is possible for the programmer to move one room and evaluate the impact on the overall layout of the facility. Beyond this, the programmer will also be affecting all of the other design elements in the facility. This takes the effort normally expended during the design process and integrates it with a knowledge base upon which each of the other facility disciplines may build.

In addition, having a footprint and massing study efficiently completed by the system based on all of the appropriate standards and guidelines frees the programmer to work more closely on the actual facility design and spend less effort repeatedly calculating design requirements. The footprint becomes the basis from which funding can be sought and a communication tool in any effort to convey facility needs. By reducing the existing CEG information to a uniquely designed footprint, it is possible to make value engineering evaluations earlier and to have the user of the facility better understand the impact of unique needs.

To accurately evaluate the performance of the SARA footprint-generating capability, incorporating the CEG databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CEG system to compare the two systems and to determine the accuracy and compatibility of SARA with the Corps of Engineers environment.

Evaluation of Item 9

Evaluate the potential for integration of the SARA System Tracking module with the CACES and CEG Database-driven project delivery system.

Summation

The SARA Program, Estimate, Schedule, and Track modules are completely interactive. During a linear project analysis, data is entered into any one of the system modules and the information automatically cascades into the subsequent modules to produce a facility program, detailed cost estimate, project schedule, schedule of values, and cash flow. To achieve a complete program analysis ranging from concept to occupancy, each SARA module is accessed. The project data developed in each of the modules references the applicable CEG and CACES databases.

It has been confirmed that the CEG program definitions, integrated with the SARA Program module, automatically generate a complete facility layout using the CEG standards. The facility program definition is automatically cascaded into the SARA Estimate module to generate a comprehensive detailed cost estimate. The development of a detailed cost estimate consists of a precise task quantity takeoff. The cost analysis is summarized as a breakdown of the equipment, labor, and materials required for the construction of the facility.

The materials included in the detailed cost estimate are retrieved from the CACES National Price Book database. A crew is dynamically developed by SARA to perform the installation of each material using the CACES Crew Composition database. The individual labor and equipment rates that make up the crew are referenced from the CACES Labor and Equipment database.

The summation of the material quantities, labor, and equipment produces the individual tasks which comprise the detailed cost estimate that, when totaled, will produce an overall project cost using the CEG and CACES databases.

SARA Methodology

The task information developed in the detailed cost estimate is automatically cascaded into the SARA Schedule module allowing a day-by-day, task-by-task schedule to be produced. The project schedule is based on a dynamic calendar and will encompass the total time required from concept to occupancy.

The project schedule is then cascaded forward into the SARA Track module. The track module serves as an information source for calculating the anticipated cash flow, and as a management tool to monitor the project budget and schedule. A schedule of values and cash flow are developed as the following:

Schedule of Values. The SARA Track module automatically develops a comprehensive schedule of values. Each of the tasks assembled in the detailed cost estimate are defined as an individual percentage of the overall project. The percentage includes the amount of equipment, labor and materials required to accomplish a task. Once the contract amount is established, each of the task percentages is then used to calculate a dollar amount for each activity.

When a change order is required, the information is entered into the SARA Estimate module as a change order. The change order data is automatically incorporated into the project schedule and then is separately maintained in the schedule of values.

The schedule of values can be used as a management tool during a pay request. The inspector uses the schedule of values to determine the completion status for each item in the pay request. SARA automatically defines whether the items are behind schedule, on schedule, or ahead of schedule and then uses the information to determine the amount of funds owed to the contractor less any retainage.

The schedule of values automatically developed by SARA increases the potential of completing the facility "on-budget" and "on-time." The schedule of values contains a detailed analysis of tasks, rather than the large groupings traditionally submitted by a contractor. This enables the project inspector to more accurately determine the completion status for each activity during a pay request.

When the schedule of values is included in the bid documents, the contractors are informed of the amount of funds allocated for each activity prior to bidding, allowing each contractor to bid competitively. When the schedule of values is included in the bid documents, the cash flow for the project will match very closely.

If the owner decides not to include the schedule of values in the bid documents, the information can be used as a negotiating tool to establish the contractor's schedule of values.

As change orders become effective, the information can be automatically maintained as a separate entity in the schedule of values. In essence, the schedule of values generated by SARA saves a significant amount of time and money because the calculations required to produce a schedule of values and pay request are performed automatically by the system.

Cash flow. The SARA Track Module automatically creates a cash flow that reflects the project schedule and schedule of values (See Appendix E). When SARA develops a cash flow, retainage percentages applicable to an organization are also automatically included in the analysis, thus producing a very accurate analysis. The cash-flow analysis can be displayed both in tabular and graphic formats.

The cash-flow analysis automatically generated by SARA provides the business officer the ability to maximize financial strategies using the time value of money. The total number of dollars required for each month during the construction phase is rapidly obtained. Since the cash-flow analysis is based on the project schedule and schedule of values, the graphic format will resemble a camel-shaped curve rather than the traditional bell shape, skewed to the left due to front end loading. When the schedule of values is included in the bid documents, typically there will be very little deviation in the cash-flow analysis.

Integration. The integration of the CACES and CEG databases with the SARA Track module required no additional efforts. When the CEG database was integrated with the SARA Program Module and the CACES databases were integrated with the SARA Estimate module, the integration requirements were complete. The schedule of values and cash flow are developed from the information contained in each of these modules; therefore no additional integration procedures were needed. Multiple projects can be combined to produce multiyear budget or funding requirement projections.

To accurately evaluate the performance of the SARA Track module, incorporating the CEG and CACES databases, the integrated systems should be used by the District Offices of the Corps of Engineers to develop projects. These projects could be executed in parallel with the existing CACES system to compare the two systems and to determine the accuracy and compatibility of SARA with the Corps of Engineers' environment.

4 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The SARA System is a unique project management program that uses data and current, state-of-the-art computer hardware and programming techniques to simplify the facility acquisition and operation process. The Sara System combines all aspects of the facility life-cycle management problem into one system that provides fair and reasonable answers based on the information available to the program when the question is posed. A review of available software has shown that no other program offers all of the features of the SARA System. This is a system that is currently available and is used by a significant number of organizations involved in capital projects procurement and management. Among the SARA System users are universities, state government agencies, county and municipal government agencies, and group organizations such as the American Hospital Association. This study has found that all of the features and functions contained within the SARA System are compatible with Corps of Engineers' facility acquisition operations. The SARA System offers its users ready access to the information necessary to effectively manage the facility delivery process.

The SARA System is capable of using the Corps of Engineers design and construction cost data and, with that information, can produce parametric cost estimates for planning, budgeting, and scheduling. While the system is producing parametric cost estimates, it is also "learning" about the various building types and creates a program data base for future use. The integration of the CEG standards into the SARA Program module helps make facility program development a quicker and more accurate process. SARA Systems and the CACES/CEG integration formalizes databases of comparative standards in the planning and construction industry. One common cause for confusion and disagreement in dealing with capital projects is the absence of a standard format for calculating and comparing project areas, costs, and schedules.

The SARA system can also produce a detailed quantity "takeoff" type of cost estimate using any cost data base conforming to the CSI identification numbering format. This includes the Corps of Engineers' prepared cost data base, the National Price Book. In addition, the integration of the CACES National Price Book into the SARA Estimate module makes it possible to develop a detailed engineered estimate using the following several methods:

1. An estimate integrated with the SARA Program module
2. An imported M-CACES estimate
3. An estimate based on a quantity takeoff method.

In all instances, the estimate can be based on the National Price Book or the SARA detailed task database, effectively tripling the amount of task information available to the estimator.

The SARA System can schedule any prepared cost estimate using the CSI format, regardless of its origin. The SARA Schedule module has also been integrated with the National Price Book to automatically produce detailed project schedules that can be generated either from existing M-CACES estimates or from estimates prepared using SARA. That is, a cost estimate created in the M-CACES program can be imported to the SARA System and scheduled, and also tracked for cash-flow projections.

Based on the cost estimate and the schedule, the SARA System can generate a comprehensive schedule of values and the cash flow requirements related to the schedule. The schedule of values and cash flow can then be used to monitor progress, validate partial payment requests, plan for payments, and evaluate timeliness.

Based on the floor area and story height guidance, the SARA System can generate spatial relationships and therefore an optimized footprint of the facility. By using the graphic interface, the programmer can quickly and accurately define a facility to the most stringent requirements. The facility definition information is produced in both tabular and graphic formats, which reflect the space relationships, structural requirements, egress requirements, and other requirements developed from the CEG system.

The SARA System can interface with the USACERL-developed Maintenance Resource Prediction Model (MRPM) to forecast the Operations and Maintenance (O&M) costs of the facility at any phase of the project's development. This projection is made based on the cost estimate, so that even at the program and planning phase, the designers and engineers can rapidly evaluate alternatives and design options not only in terms of construction cost, but also in terms of life-cycle O&M cost. This capability also facilitates the impact of Value Engineering (VE) by introducing the long term O&M cost into the process.

The resulting system of unified calculation and reporting creates environment-specific databases that provide accurate and dependable project information for planning and comparison purposes. These integrated databases are used for coordinated project programming, budgeting, cost projection, scheduling, and tracking for the Corps of Engineers. Effective use of the SARA System for Corps projects would best be supported by a single point-of-project management, from concept through occupancy, an operational concept common to the private sector and often considered for Corps implementation.

The possibility of providing the Corps of Engineers with an integrated project delivery system capable of taking a project from concept to occupancy and through to disposal based on data specific to the Corps of Engineers, is now available by integrating the SARA System with the Corps of Engineers CACES program. Such integration should improve the productivity of the facility acquisition professional through effective and efficient access to information for decisionmaking.

Recommendations

It is recommended that the SARA System be incorporated into Corps of Engineers operations by:

1. Field testing the SARA System at several District/Division offices. The test should include all functional aspects of the system including the program, estimating, scheduling, tracking, and footprint-generating capabilities.

2. Conducting a longitudinal evaluation test of the SARA System using the Corps of Engineers data, and comparing the results with traditional Corps of Engineers methods and procedures. This test should track several projects completely through the facility acquisition cycle to occupancy.

3. Conducting a cross-sectional evaluation test of the SARA System using the Corps of Engineers data, and comparing the results with traditional Corps of Engineers methods and procedures. This test should compare a variety of projects at various phases and stages of completion, from the planning and programming phase to the owner occupancy and feedback phase.

4. Establishing a user group to help evaluate the test results and review the findings. This peer review group would establish the test criteria, the test measurements, and the system acceptance. The group would review all phases of the process represented, and would advise as to the need for acquiring the capacity.

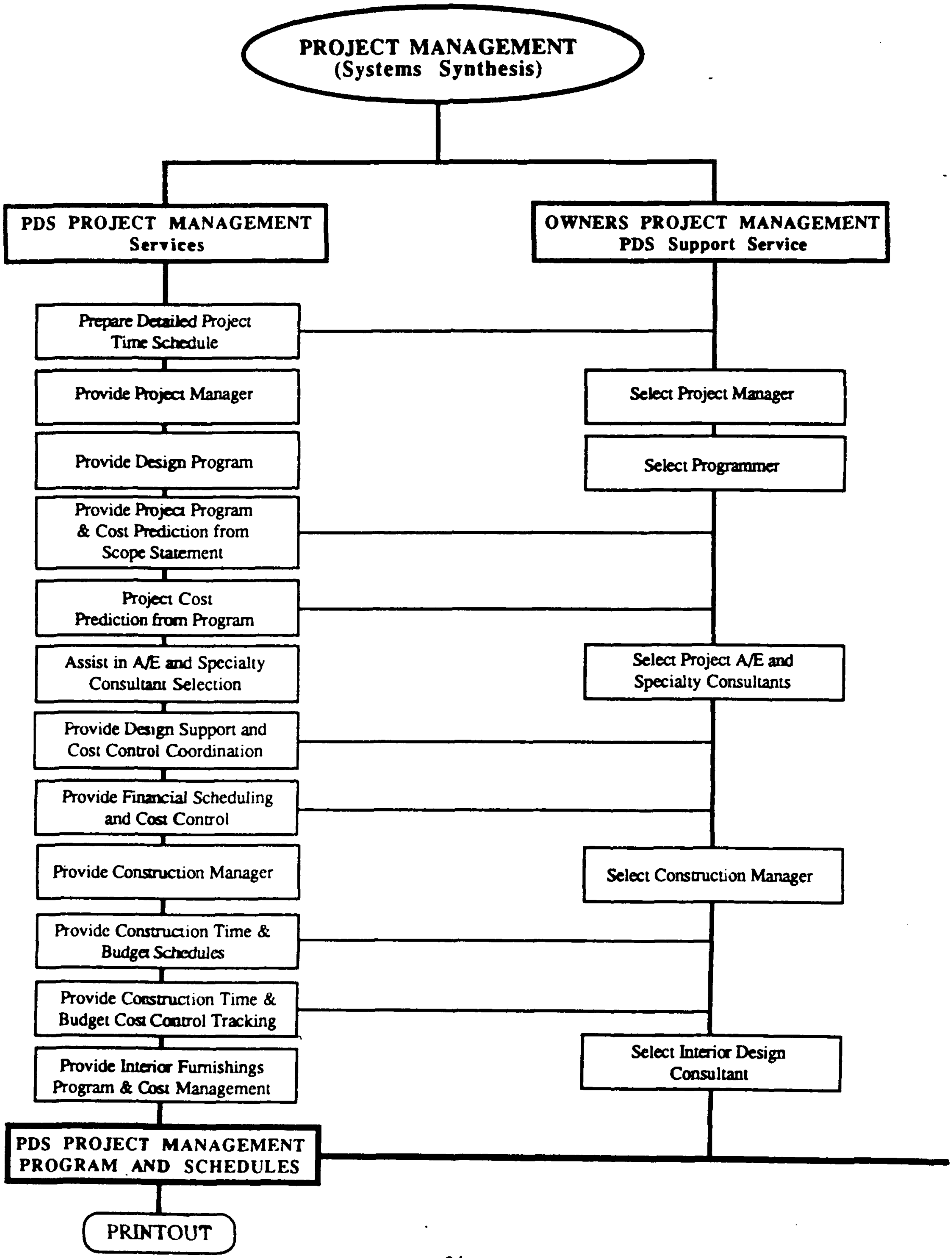
ENDNOTES

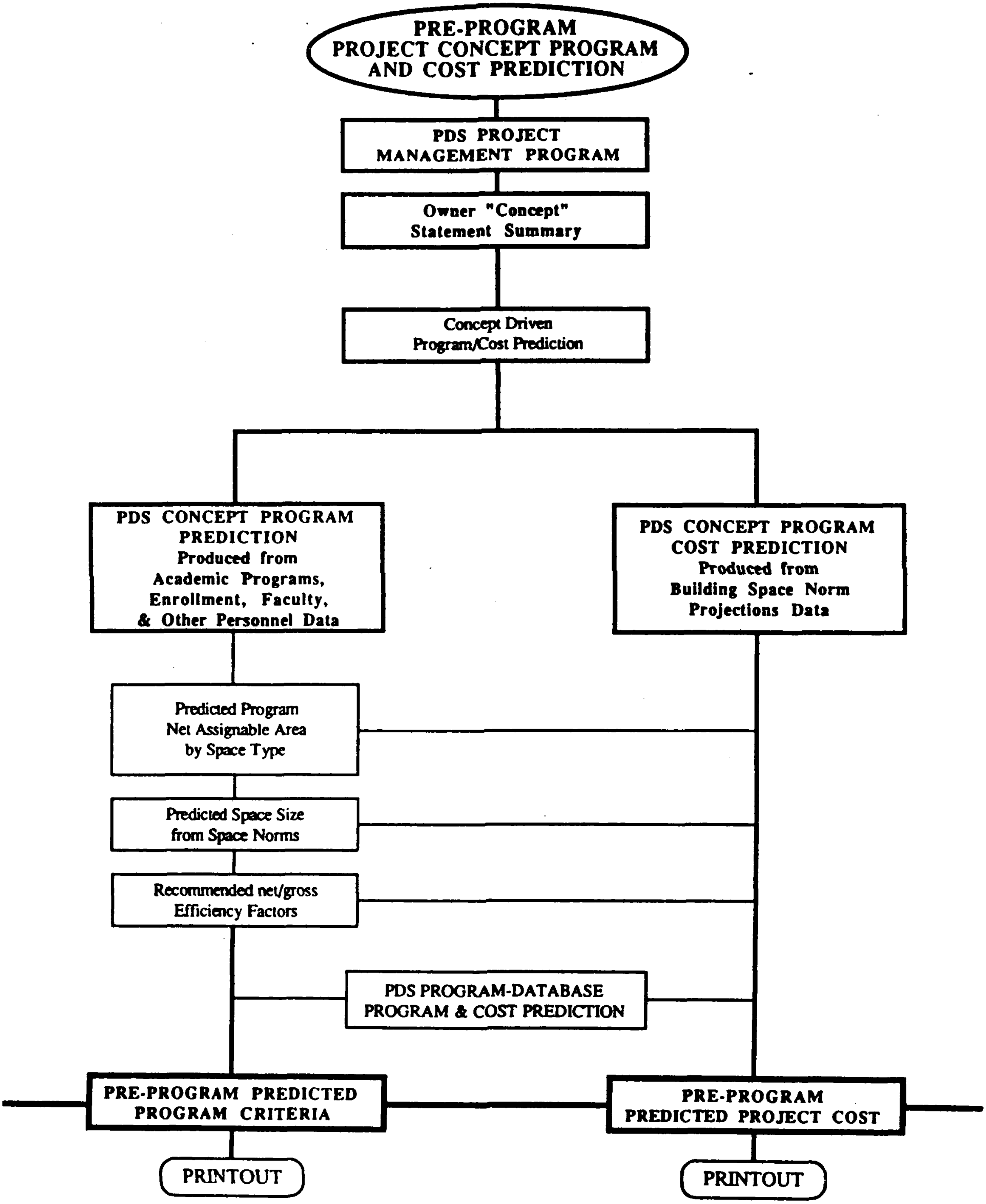
1. Edgar Neely, *Maintenance Resource Prediction Model Summary System (MRPMS) User's Manual*, Automated Data Processing (ADP) Report P-91/03/ADA228907 (U.S. Army Construction Engineering Research Laboratory [USACERL], October 1990).

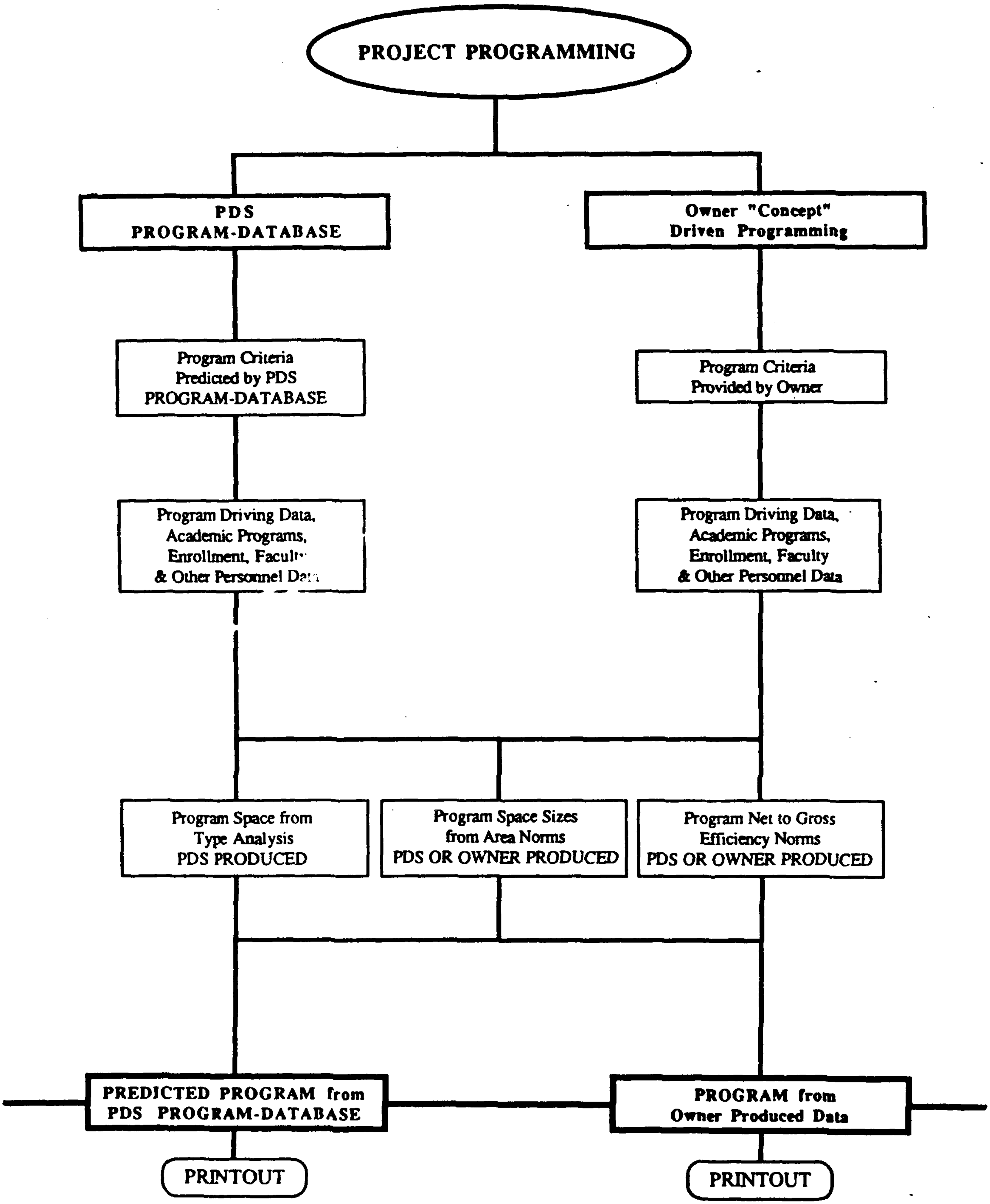
2. *Micro-Computer Aided Cost Engineering System* (Corps of Engineers, Huntsville Division, Huntsville, AL).

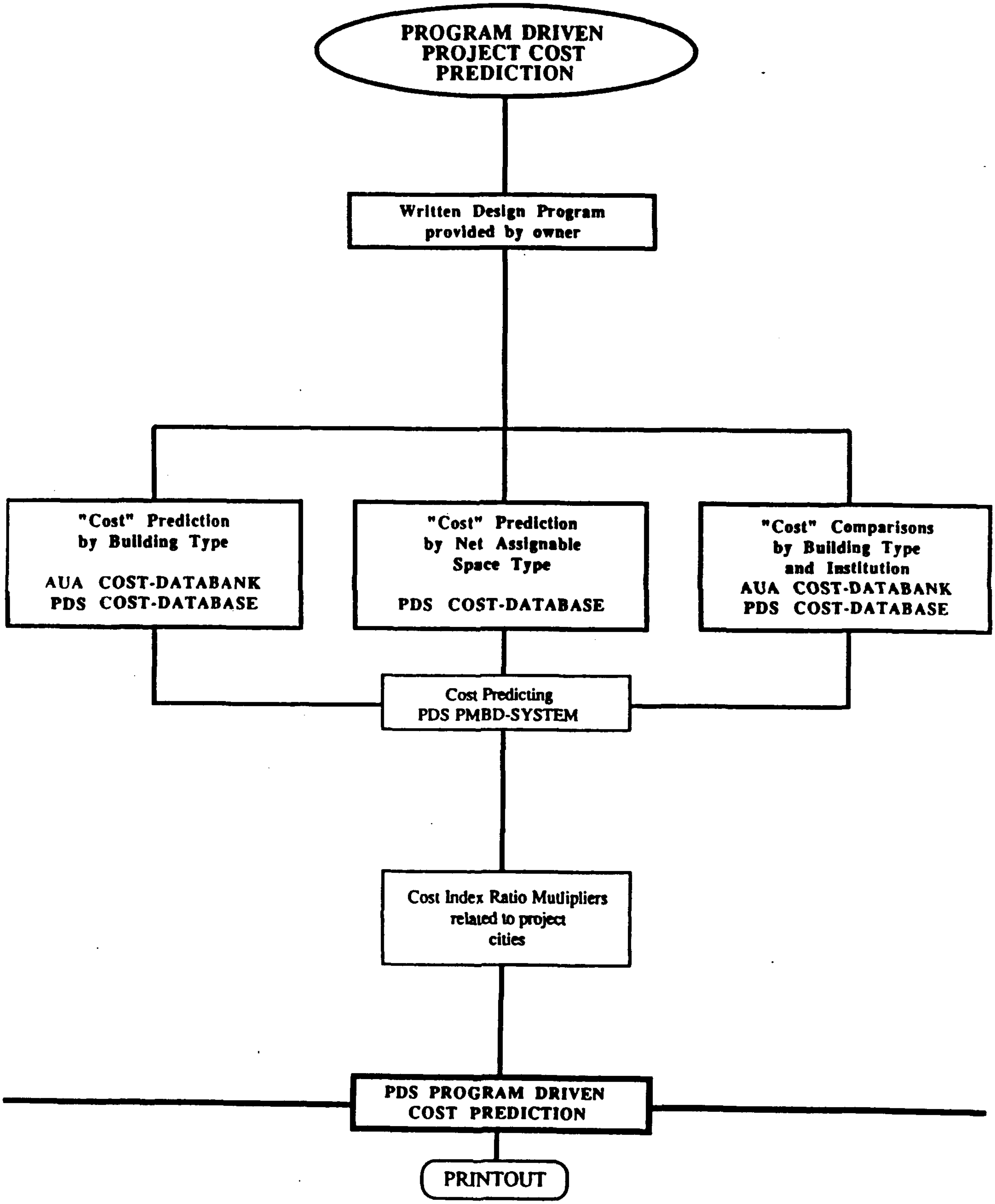
3. *CACES Crew Composition Database Reference Manual* (Corps of Engineers, Huntsville Division, Huntsville, AL, 1988).

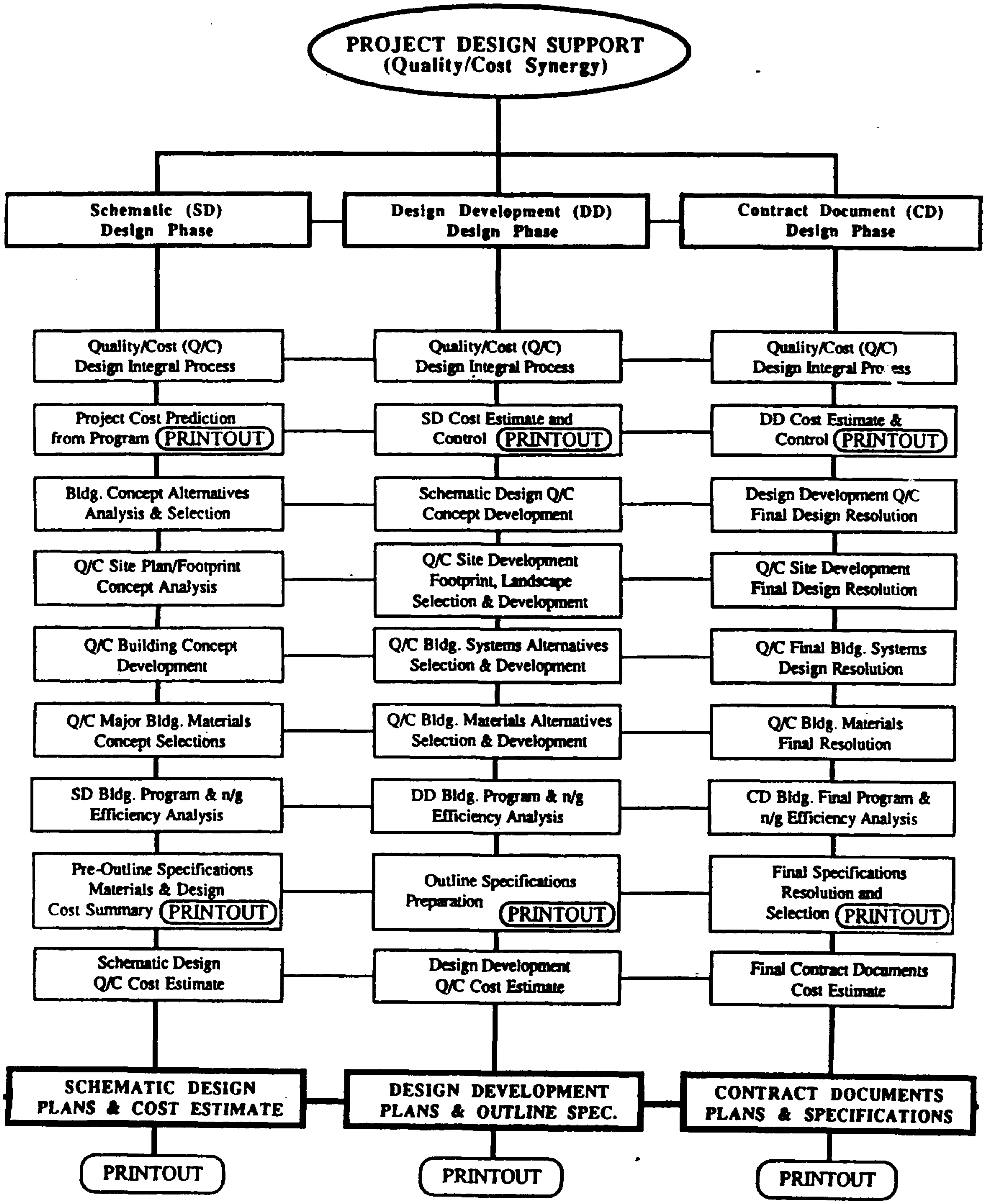
APPENDIX A: SARA Project Management Services Diagram

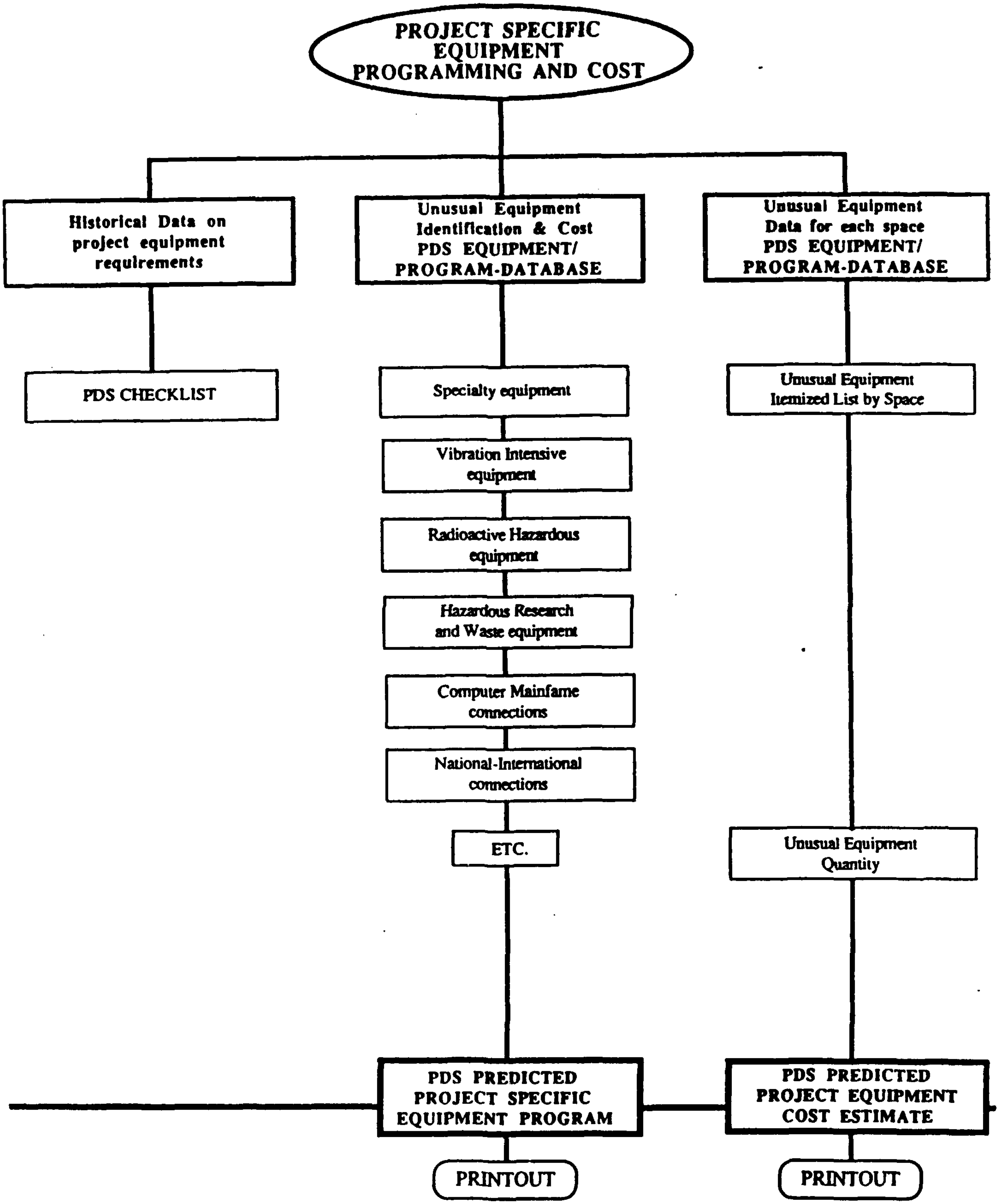

PROJECT MANAGEMENT
(Systems Synthesis)
PDS PROJECT MANAGEMENT
Services
OWNERS PROJECT MANAGEMENT
PDS Support Service
Prepare Detailed Project Time Schedule
Provide Project Manager
Select Project Manager
Provide Design Program
Select Programmer
Provide Project Program & Cost Prediction from Scope Statement
Project Cost Prediction from Program
Assist in A/E and Specialty Consultant Selection
Select Project A/E and Specialty Consultants
Provide Design Support and Cost Control Coordination
Provide Financial Scheduling and Cost Control
Provide Construction Manager
Select Construction Manager
Provide Construction Time & Budget Schedules
Provide Construction Time & Budget Cost Control Tracking
Provide Interior Furnishings Program & Cost Management
Select Interior Design Consultant
PDS PROJECT MANAGEMENT
PROGRAM AND SCHEDULES
PRINTOUT

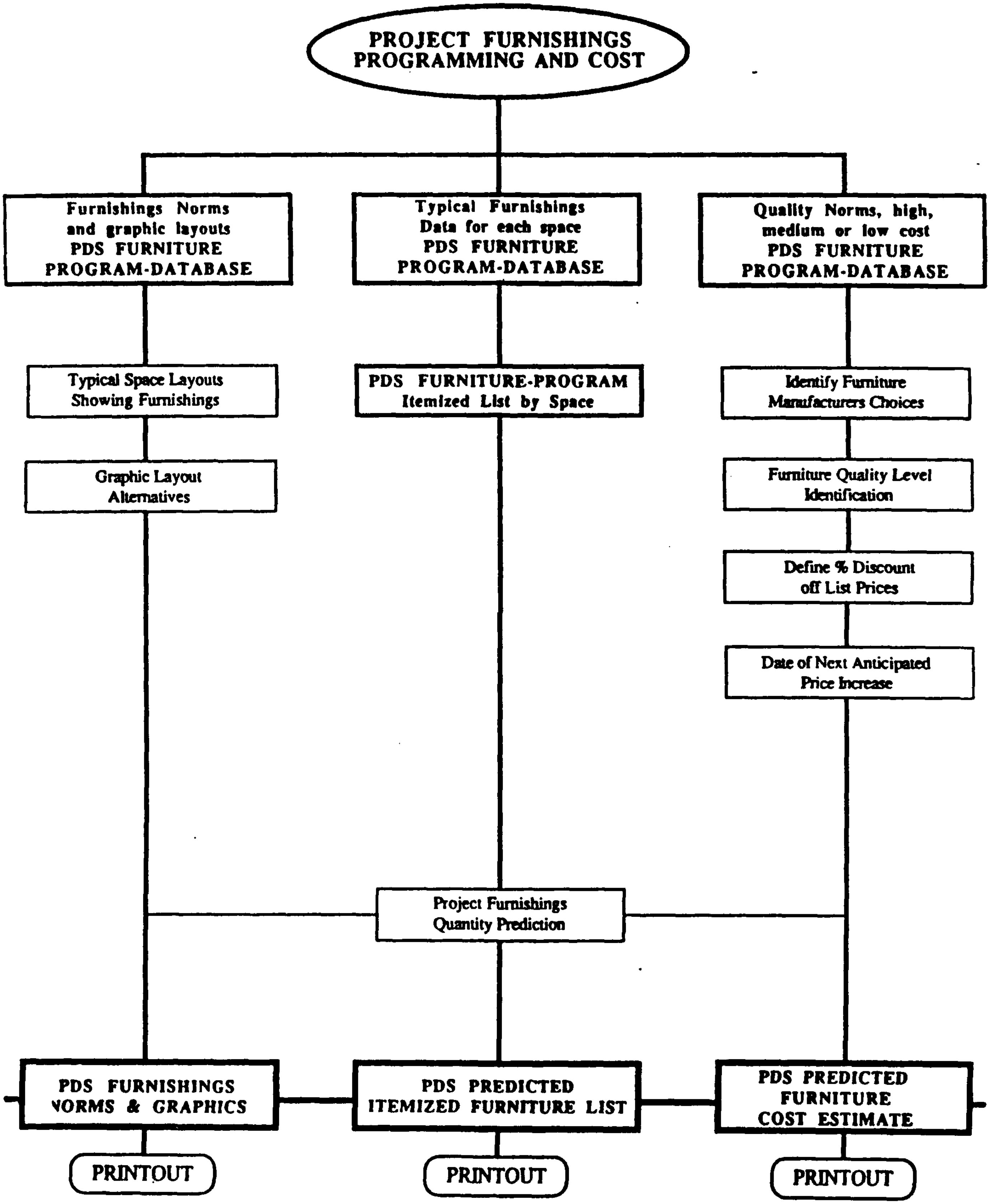

PRE-PROGRAM
PROJECT CONCEPT PROGRAM
AND COST PREDICTION
PDS PROJECT
MANAGEMENT PROGRAM
Owner "Concept"
Statement Summary
Concept Driven
Program/Cost Prediction
PDS CONCEPT PROGRAM
PREDICTION
Produced from
Academic Programs,
Enrollment, Faculty,
& Other Personnel Data
PDS CONCEPT PROGRAM
COST PREDICTION
Produced from
Building Space Norm
Projections Data
Predicted Program
Net Assignable Area
by Space Type
Predicted Space Size
from Space Norms
Recommended net/gross
Efficiency Factors
PDS PROGRAM-DATABASE
PROGRAM & COST PREDICTION
PRE-PROGRAM PREDICTED
PROGRAM CRITERIA
PRE-PROGRAM
PREDICTED PROJECT COST
PRINTOUT
PRINTOUT


PROJECT PROGRAMMING
PDS PROGRAM-DATABASE
Owner "Concept" Driven Programming
Program Criteria Predicted by PDS PROGRAM-DATABASE
Program Criteria Provided by Owner
Program Driving Data, Academic Programs, Enrollment, Faculty & Other Personnel Data
Program Driving Data, Academic Programs, Enrollment, Faculty & Other Personnel Data
Program Space from Type Analysis PDS PRODUCED
Program Space Sizes from Area Norms PDS OR OWNER PRODUCED
Program Net to Gross Efficiency Norms PDS OR OWNER PRODUCED
PREDICTED PROGRAM from PDS PROGRAM-DATABASE
PROGRAM from Owner Produced Data
PRINTOUT
PRINTOUT

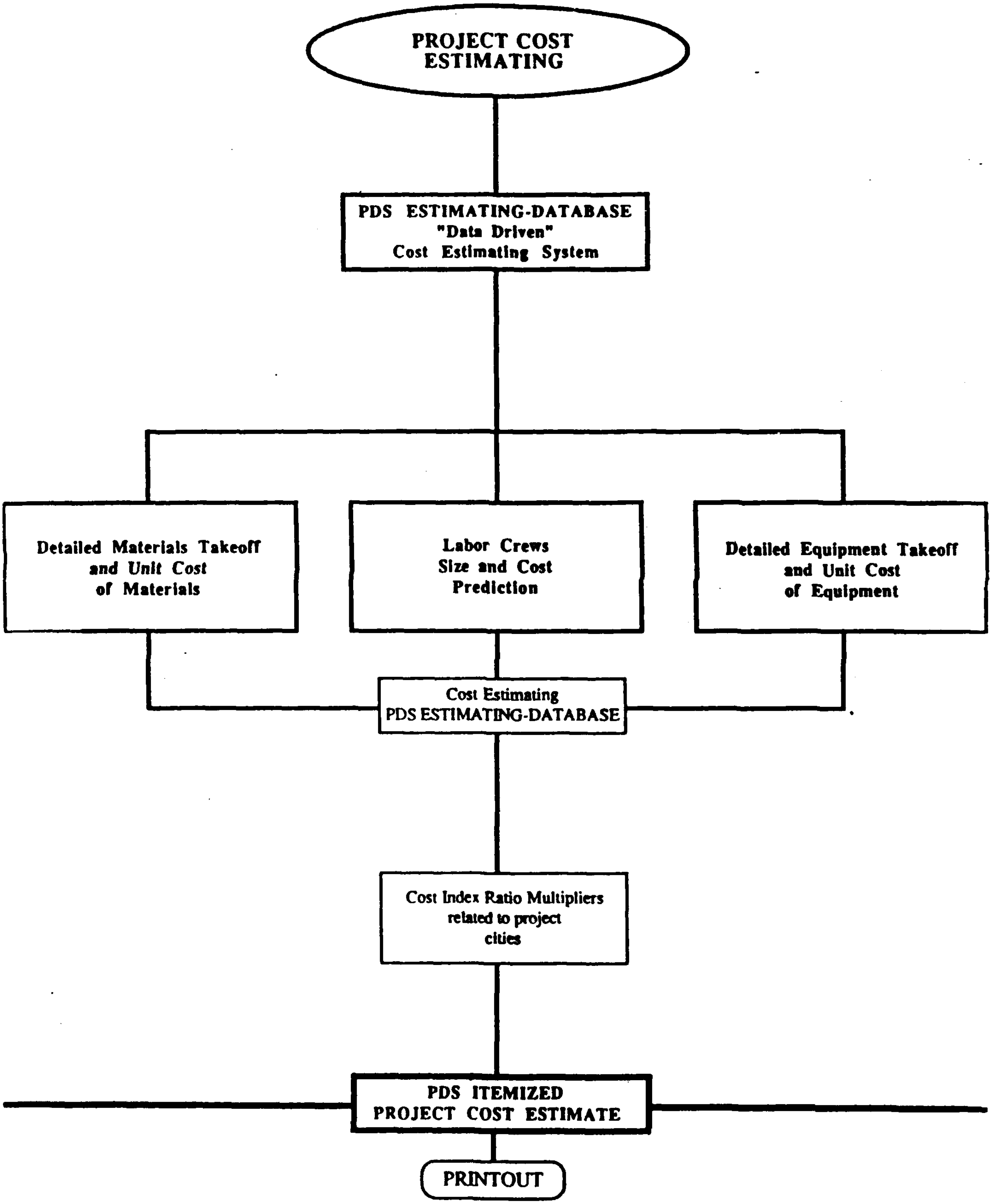

PROGRAM DRIVEN PROJECT COST PREDICTION
Written Design Program provided by owner
"Cost" Prediction by Building Type
AUA COST-DATABANK
PDS COST-DATABASE
"Cost" Prediction by Net Assignable Space Type
PDS COST-DATABASE
"Cost" Comparisons by Building Type and Institution
AUA COST-DATABANK
PDS COST-DATABASE
Cost Predicting PDS PMBD-SYSTEM
Cost Index Ratio Mutlipliers related to project cities
PDS PROGRAM DRIVEN COST PREDICTION
PRINTOUT

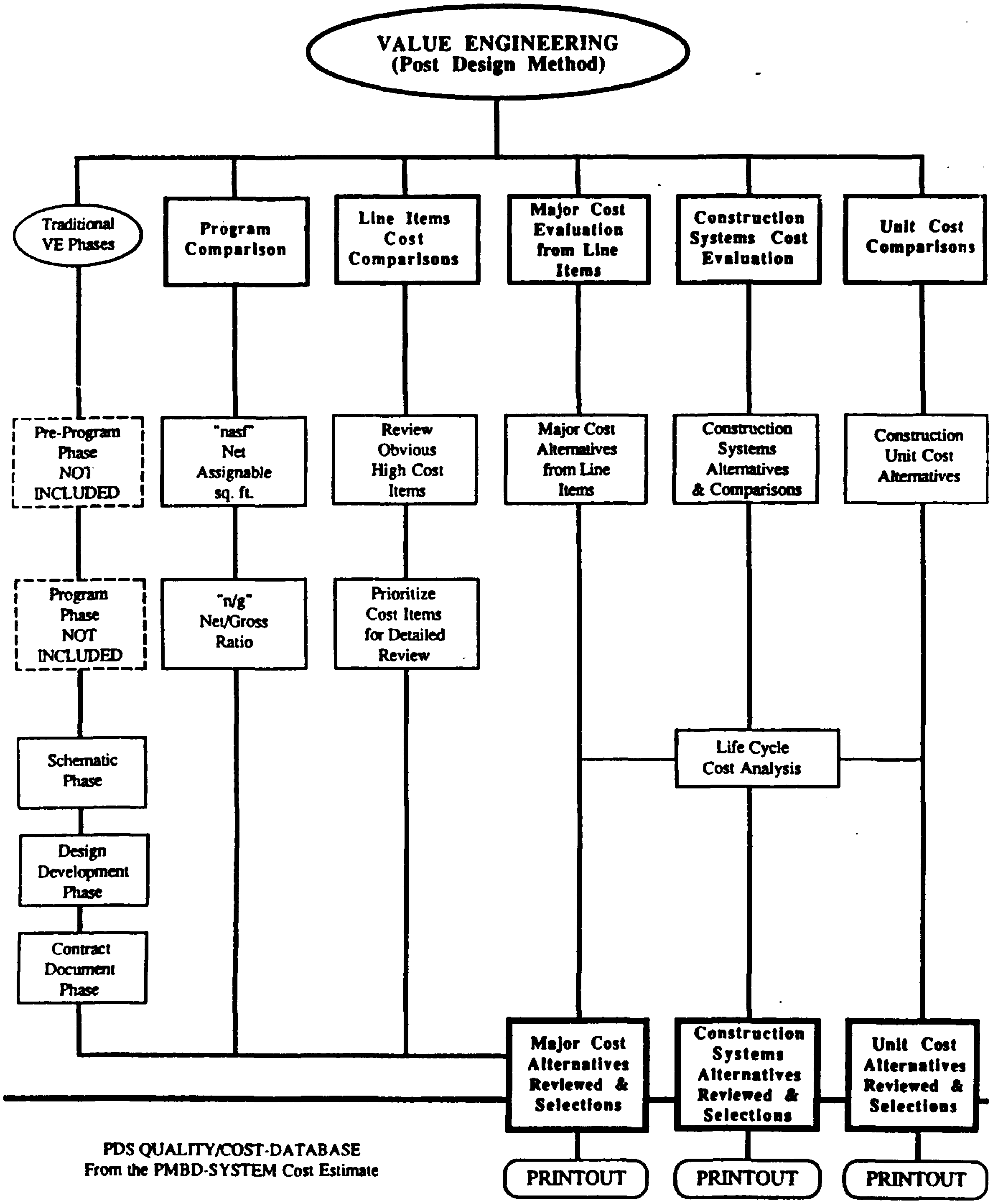

PROJECT DESIGN SUPPORT
(Quality/Cost Synergy)
Schematic (SD) Design Phase
Design Development (DD) Design Phase
Contract Document (CD) Design Phase
Quality/Cost (Q/C) Design Integral Process
Quality/Cost (Q/C) Design Integral Process
Quality/Cost (Q/C) Design Integral Process
Project Cost Prediction from Program PRINTOUT
SD Cost Estimate and Control PRINTOUT
DD Cost Estimate & Control PRINTOUT
Bldg. Concept Alternatives Analysis & Selection
Schematic Design Q/C Concept Development
Design Development Q/C Final Design Resolution
Q/C Site Plan/Footprint Concept Analysis
Q/C Site Development Footprint, Landscape Selection & Development
Q/C Site Development Final Design Resolution
Q/C Building Concept Development
Q/C Bldg. Systems Alternatives Selection & Development
Q/C Final Bldg. Systems Design Resolution
Q/C Major Bldg. Materials Concept Selections
Q/C Bldg. Materials Alternatives Selection & Development
Q/C Bldg. Materials Final Resolution
SD Bldg. Program & n/g Efficiency Analysis
DD Bldg. Program & n/g Efficiency Analysis
CD Bldg. Final Program & n/g Efficiency Analysis
Pre-Outline Specifications Materials & Design Cost Summary PRINTOUT
Outline Specifications Preparation PRINTOUT
Final Specifications Resolution and Selection PRINTOUT
Schematic Design Q/C Cost Estimate
Design Development Q/C Cost Estimate
Final Contract Documents Cost Estimate
SCHEMATIC DESIGN PLANS & COST ESTIMATE
DESIGN DEVELOPMENT PLANS & OUTLINE SPEC.
CONTRACT DOCUMENTS PLANS & SPECIFICATIONS
PRINTOUT
PRINTOUT
PRINTOUT


PROJECT SPECIFIC EQUIPMENT PROGRAMMING AND COST
Historical Data on project equipment requirements
Unusual Equipment Identification & Cost PDS EQUIPMENT/ PROGRAM-DATABASE
Unusual Equipment Data for each space PDS EQUIPMENT/ PROGRAM-DATABASE
PDS CHECKLIST
Specialty equipment
Vibration Intensive equipment
Radioactive Hazardous equipment
Hazardous Research and Waste equipment
Computer Mainfame connections
National-International connections
ETC.
Unusual Equipment Itemized List by Space
Unusual Equipment Quantity
PDS PREDICTED PROJECT SPECIFIC EQUIPMENT PROGRAM
PDS PREDICTED PROJECT EQUIPMENT COST ESTIMATE
PRINTOUT
PRINTOUT

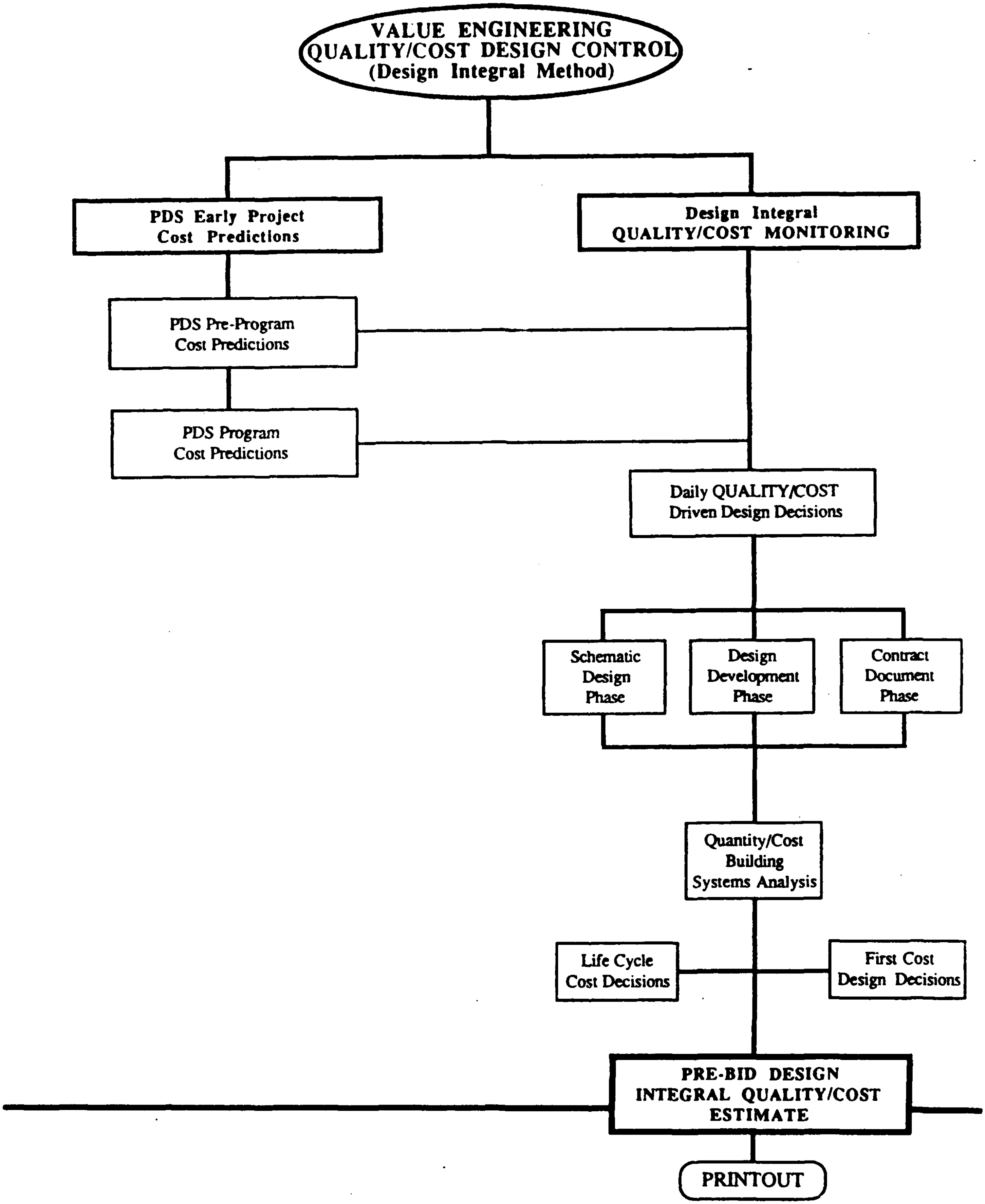


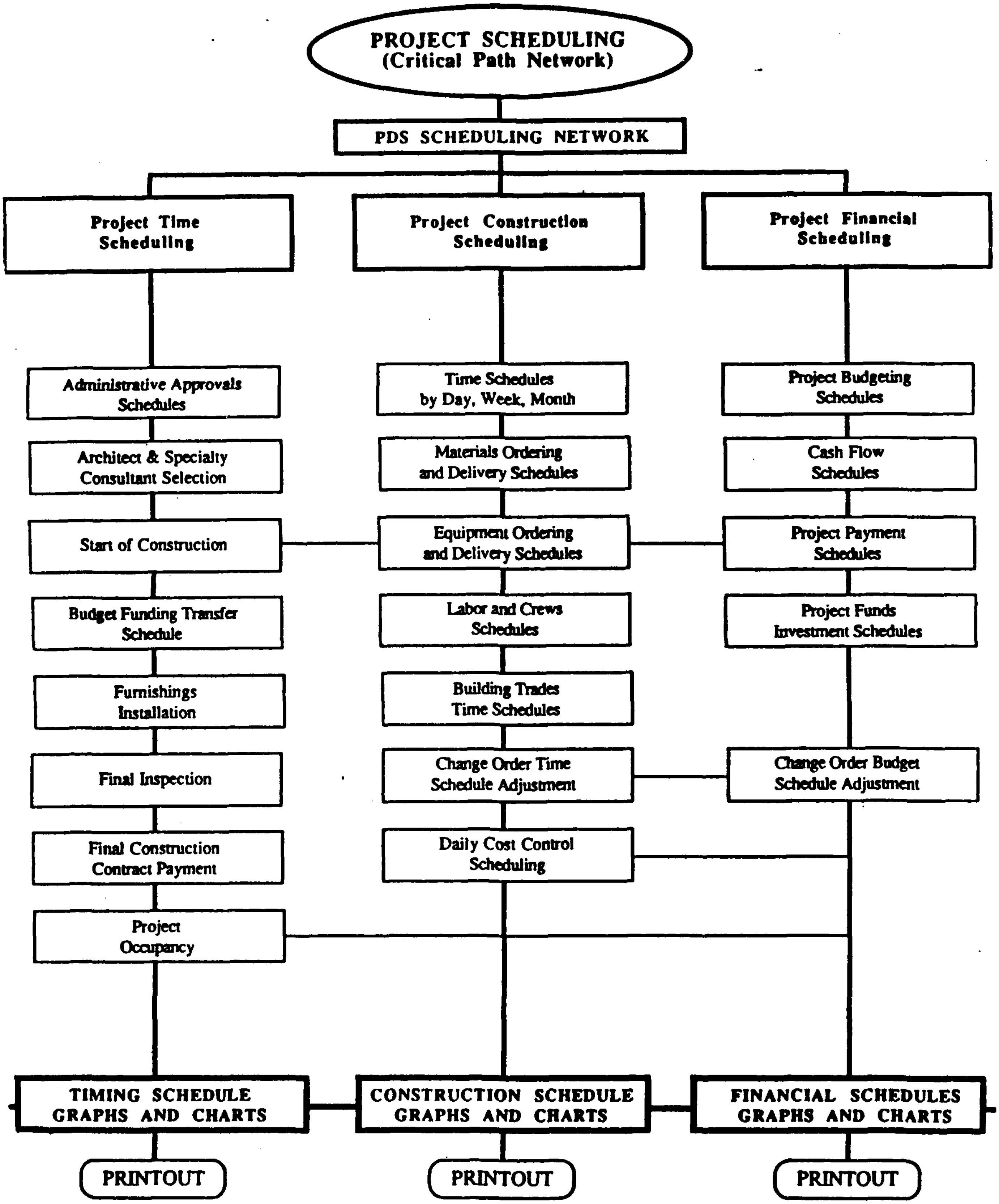
PROJECT FURNISHINGS PROGRAMMING AND COST
Furnishings Norms and graphic layouts PDS FURNITURE PROGRAM-DATABASE
Typical Furnishings Data for each space PDS FURNITURE PROGRAM-DATABASE
Quality Norms, high, medium or low cost PDS FURNITURE PROGRAM-DATABASE
Typical Space Layouts Showing Furnishings
PDS FURNITURE-PROGRAM Itemized List by Space
Identify Furniture Manufacturers Choices
Graphic Layout Alternatives
Furniture Quality Level Identification
Define % Discount off List Prices
Date of Next Anticipated Price Increase
Project Furnishings Quantity Prediction
PDS FURNISHINGS NORMS & GRAPHICS
PDS PREDICTED ITEMIZED FURNITURE LIST
PDS PREDICTED FURNITURE COST ESTIMATE
PRINTOUT
PRINTOUT
PRINTOUT

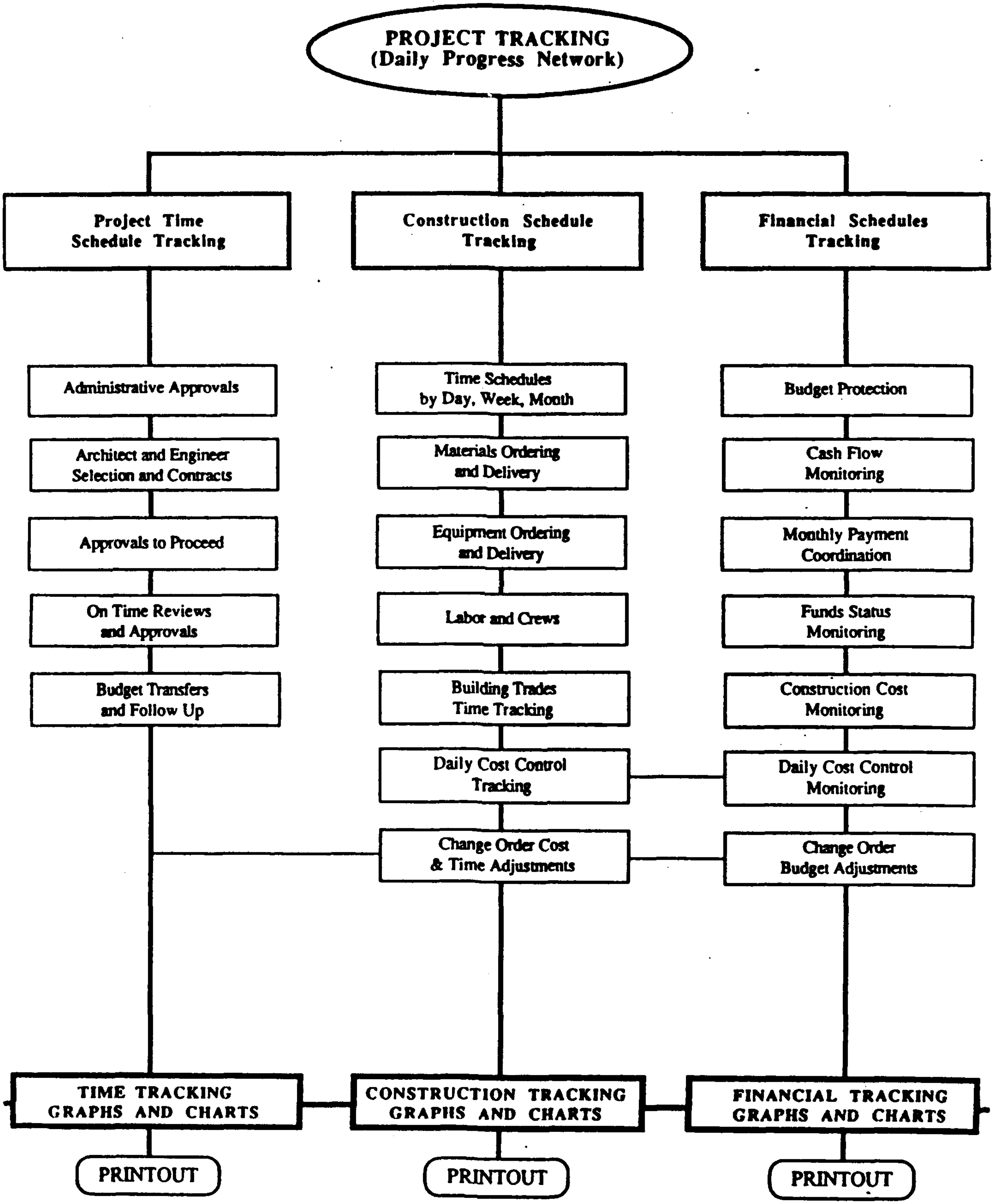

PROJECT COST ESTIMATING
PDS ESTIMATING-DATABASE "Data Driven" Cost Estimating System
Detailed Materials Takeoff and Unit Cost of Materials
Labor Crews Size and Cost Prediction
Detailed Equipment Takeoff and Unit Cost of Equipment
Cost Estimating PDS ESTIMATING-DATABASE
Cost Index Ratio Multipliers related to project cities
PDS ITEMIZED PROJECT COST ESTIMATE
PRINTOUT

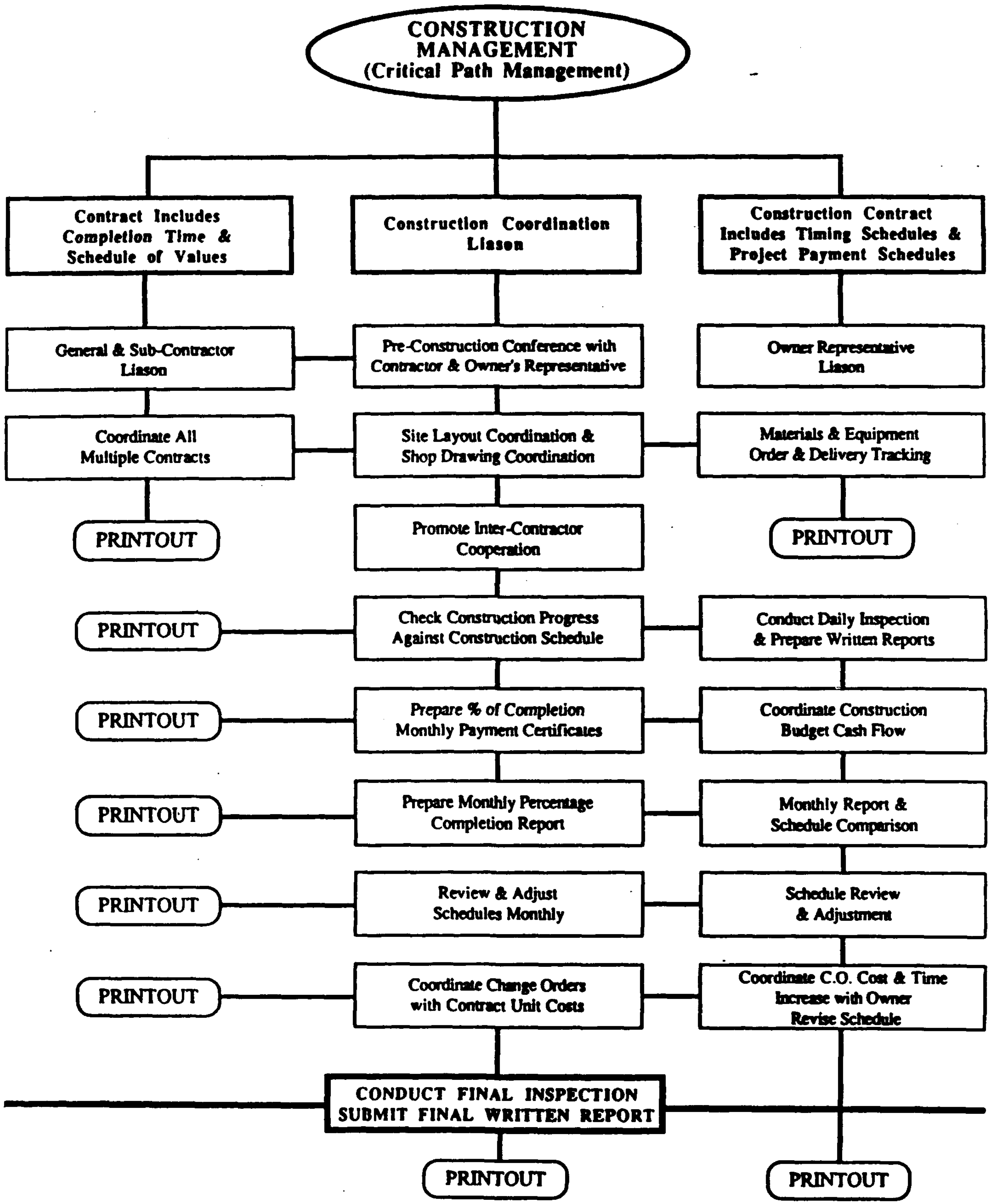


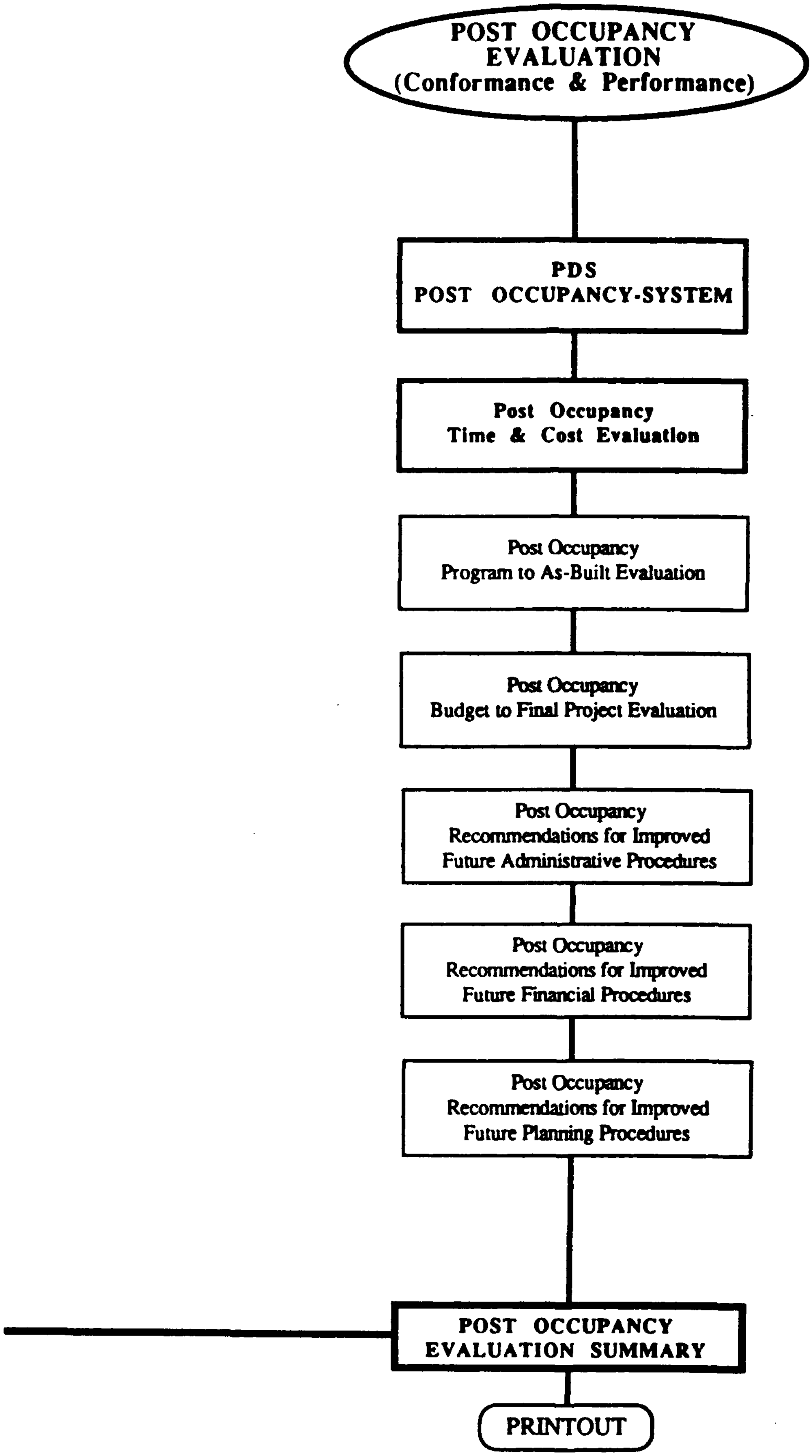
PDS QUALITY/COST-DATABASE
From the PMBD-SYSTEM Cost Estimate


VALUE ENGINEERING
QUALITY/COST DESIGN CONTROL
(Design Integral Method)
PDS Early Project
Cost Predictions
Design Integral
QUALITY/COST MONITORING
PDS Pre-Program
Cost Predictions
PDS Program
Cost Predictions
Daily QUALITY/COST
Driven Design Decisions
Schematic
Design
Phase
Design
Development
Phase
Contract
Document
Phase
Quantity/Cost
Building
Systems Analysis
Life Cycle
Cost Decisions
First Cost
Design Decisions
PRE-BID DESIGN
INTEGRAL QUALITY/COST
ESTIMATE
PRINTOUT


PROJECT SCHEDULING
(Critical Path Network)
PDS SCHEDULING NETWORK
Project Time Scheduling
Project Construction Scheduling
Project Financial Scheduling
Administrative Approvals Schedules
Architect & Specialty Consultant Selection
Start of Construction
Budget Funding Transfer Schedule
Furnishings Installation
Final Inspection
Final Construction Contract Payment
Project Occupancy
Time Schedules by Day, Week, Month
Materials Ordering and Delivery Schedules
Equipment Ordering and Delivery Schedules
Labor and Crews Schedules
Building Trades Time Schedules
Change Order Time Schedule Adjustment
Daily Cost Control Scheduling
Project Budgeting Schedules
Cash Flow Schedules
Project Payment Schedules
Project Funds Investment Schedules
Change Order Budget Schedule Adjustment
TIMING SCHEDULE GRAPHS AND CHARTS
CONSTRUCTION SCHEDULE GRAPHS AND CHARTS
FINANCIAL SCHEDULES GRAPHS AND CHARTS
PRINTOUT
PRINTOUT
PRINTOUT


PROJECT TRACKING
(Daily Progress Network)
Project Time Schedule Tracking
Construction Schedule Tracking
Financial Schedules Tracking
Administrative Approvals
Architect and Engineer Selection and Contracts
Approvals to Proceed
On Time Reviews and Approvals
Budget Transfers and Follow Up
Time Schedules by Day, Week, Month
Materials Ordering and Delivery
Equipment Ordering and Delivery
Labor and Crews
Building Trades Time Tracking
Daily Cost Control Tracking
Change Order Cost & Time Adjustments
Budget Protection
Cash Flow Monitoring
Monthly Payment Coordination
Funds Status Monitoring
Construction Cost Monitoring
Daily Cost Control Monitoring
Change Order Budget Adjustments
TIME TRACKING GRAPHS AND CHARTS
CONSTRUCTION TRACKING GRAPHS AND CHARTS
FINANCIAL TRACKING GRAPHS AND CHARTS
PRINTOUT
PRINTOUT
PRINTOUT


CONSTRUCTION MANAGEMENT (Critical Path Management)
Contract Includes Completion Time & Schedule of Values
Construction Coordination Liason
Construction Contract Includes Timing Schedules & Project Payment Schedules
General & Sub-Contractor Liason
Pre-Construction Conference with Contractor & Owner's Representative
Owner Representative Liason
Coordinate All Multiple Contracts
Site Layout Coordination & Shop Drawing Coordination
Materials & Equipment Order & Delivery Tracking
PRINTOUT
Promote Inter-Contractor Cooperation
PRINTOUT
PRINTOUT
Check Construction Progress Against Construction Schedule
Conduct Daily Inspection & Prepare Written Reports
PRINTOUT
Prepare % of Completion Monthly Payment Certificates
Coordinate Construction Budget Cash Flow
PRINTOUT
Prepare Monthly Percentage Completion Report
Monthly Report & Schedule Comparison
PRINTOUT
Review & Adjust Schedules Monthly
Schedule Review & Adjustment
PRINTOUT
Coordinate Change Orders with Contract Unit Costs
Coordinate C.O. Cost & Time Increase with Owner Revise Schedule
CONDUCT FINAL INSPECTION SUBMIT FINAL WRITTEN REPORT
PRINTOUT
PRINTOUT


POST OCCUPANCY EVALUATION (Conformance & Performance)
PDS POST OCCUPANCY-SYSTEM
Post Occupancy Time & Cost Evaluation
Post Occupancy Program to As-Built Evaluation
Post Occupancy Budget to Final Project Evaluation
Post Occupancy Recommendations for Improved Future Administrative Procedures
Post Occupancy Recommendations for Improved Future Financial Procedures
Post Occupancy Recommendations for Improved Future Planning Procedures
POST OCCUPANCY EVALUATION SUMMARY
PRINTOUT

APPENDIX B: SARA Output of Facility Program Requirements

1/06/80

Project Management System

PROJECT NAME :

LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR :

COORDINATOR :

STAGE OF ESTIMATE :

FSI Program Summary

Function	#/RM	nsf	gsf	Cost	Cost/gsf	Equipment
day-care homebase (infant)	1	587	587	43,121	73.46	7,331
day-care homebase (toddler)	1	521	521	38,273	73.46	6,506
day-care homebase (pre-school)	1	391	391	28,723	73.46	4,883
day-care shared space (infant)	1	287	287	23,718	82.64	4,032
day-care shared space toddler	1	167	167	13,801	82.64	2,346
day-care shared space pre-schl	1	104	104	8,595	82.64	1,461
day-care shared space school	1	235	235	19,420	82.64	3,301
day-care outside (infant)	1	0	651	29,887	45.91	5,081
day-care outside (toddler)	1	0	1,563	36,684	23.47	6,236
day-care outside (pre-school)	1	0	2,605	31,885	12.24	5,420
day-care outside (school)	1	0	8,597	78,920	9.18	13,416
day-care motor area toddler	1	125	125	10,840	86.72	1,843
day-care motor area pre-school	1	208	208	18,674	89.78	3,175
day-care motor area school	1	235	235	21,338	90.80	3,627
day-care sensory area toddler	1	125	125	10,585	84.68	1,799
day-care sensory area pre-schl	1	208	208	17,826	85.70	3,030
day-care sensory area school	1	235	235	20,379	86.72	3,464
day-care group activities pre	1	208	208	15,280	73.46	2,597
day-care group activities schl	1	313	313	24,270	77.54	4,126
day-care learning center schl	1	313	313	24,589	78.56	4,180
work room	1	110	110	8,081	73.46	1,131
kitchen/residential	1	90	90	6,244	69.38	2,061
administration offices	1	143	143	10,651	74.48	1,704
laundry room	1	143	143	15,320	107.13	3,064
foyer	1	0	180	15,610	86.72	468
office ancillary	2	32	32	2,024	63.25	102
office	2	286	286	19,842	69.38	2,976
dining area(residence)	1	567	567	31,814	56.11	3,181
kitchen storage/residential	1	80	80	4,897	61.21	245
secretary administrative	1	120	120	8,326	69.38	1,082
hall	1	0	2,223	154,232	69.38	1,536
mechanical/chase	1	0	76	4,652	61.21	0
electrical	1	0	57	4,536	79.58	286
janitor	1	0	76	6,978	91.82	0
restroom(multi-person)	1	0	324	34,710	107.13	0
walls/building	1	0	2,281	93,088	40.81	0
mechanical & electrical vault	1	0	923	207,167	224.45	0
Total	39	5,833	25,389	1,144,980	45.10	105,690

1/06/80

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

AREA DISPLAY

Zone	Rm #	FSI	Function Description	A/N	NSF	$/NSF	BLDG TOTAL	EQ TOTAL	SF/O	OCC
L1 A	101	18 1 10 3001	day-care homebase (infant)	A	587	73.46	43121	7331	45	13
L1 A	102	18 1 10 3002	day-care homebase (toddler)	A	521	73.46	38273	6506	25	21
L1 A	103	18 1 10 3003	day-care homebase (pre-school)	A	391	73.46	28723	4883	15	26
L1 A	104	18 1 10 3004	day-care shared space (infant)	A	287	82.64	23718	4032	22	13
L1 A	105	18 1 10 3005	day-care shared space toddler	A	167	82.64	13801	2346	8	21
L1 A	106	18 1 10 3006	day-care shared space pre-schl	A	104	82.64	8595	1461	4	26
L1 A	107	18 1 10 3007	day-care shared space school	A	235	82.64	19420	3301	6	39
L1 A	108	18 1 10 3012	day-care motor area toddler	A	125	86.72	10840	1843	6	21
L1 A	109	18 1 10 3013	day-care motor area pre-school	A	208	89.78	18674	3175	8	26
L1 A	110	18 1 10 3014	day-care motor area school	A	235	90.80	21338	3627	6	39
L1 A	111	18 1 10 3015	day-care sensory area toddler	A	125	84.68	10585	1799	6	21
L1 A	112	18 1 10 3016	day-care sensory area pre-schl	A	208	85.70	17826	3030	8	26
L1 A	113	18 1 10 3017	day-care sensory area school	A	235	86.72	20379	3464	6	39
L1 A	114	18 1 10 3018	day-care group activities pre	A	208	73.46	15280	2597	8	26
L1 A	115	18 1 10 3019	day-care group activities schl	A	313	77.54	24270	4126	8	39
L1 A	116	18 1 10 3020	day-care learning center schl	A	313	78.56	24589	4180	8	39
L1 A	117	18 1 10 1912	work room	A	110	73.46	8081	1131	140	1
L1 A	118	18 1 10 890	kitchen/residential	A	90	69.38	6244	2061	120	1
L1 A	119	18 1 10 20	administration offices	A	143	74.48	10651	1704	144	1
L1 A	120	18 1 10 980	laundry room	A	143	107.13	15320	3064	100	1
L1 A	121	18 1 10 730	foyer	N	180	86.72	15610	468	20	9
L1 A	122	18 1 10 1291	office ancillary	A	16	63.26	1012	51	15	1
L1 A	123	18 1 10 1291	office ancillary	A	16	63.26	1012	51	15	1
L1 A	124	18 1 10 1290	office	A	143	69.38	9921	1488	144	1
L1 A	125	18 1 10 1290	office	A	143	69.38	9921	1488	144	1
L1 A	126	18 1 10 560	dining area(residence)	A	567	56.11	31814	3181	20	28
L1 A	127	18 1 10 911	kitchen storage/residential	A	80	61.21	4897	245	0	0
L1 A	128	18 1 10 1581	secretary administrative	A	120	69.38	8326	1082	120	1
L1 A	129	18 1 10 1920	hall	N	1200	69.38	83256	833	0	0
L1 A	130	18 1 10 1160	mechanical/chase	N	24	61.21	1469	0	*	0
L1 A	131	18 1 10 611	electrical	N	18	79.58	1432	286	25	1
L1 A	132	18 1 10 880	janitor	N	24	91.82	2204	0	0	0
L1 A	133	18 1 10 1530	restroom(multi-person)	N	282	107.13	30211	0	30	9
L1 A	134	18 1 10 1910	walls/building	N	1500	40.81	61215	0	*	0
L1 A	135	18 1 10 1150	mechanical & electrical vault	N	415	224.45	93147	0	*	0

1/06/80

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

FSI Zone Summary

Zone	n/g	nsf	gsf	Cost	Cost/gsf	Equipment
L1 A	0.62	5,833	9,476	735,175	77.58	74,834
Total	0.62	5,833	9,476	735,175	77.58	74,834

1/06/80

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

FSI Program Summary

Function	#/RM	nsf	gsf	Cost	Cost/gsf	Equipment
day-care homebase (infant)	1	587	587	43,121	73.46	7,331
day-care homebase (toddler)	1	521	521	38,273	73.46	6,506
day-care homebase (pre-school)	1	391	391	28,723	73.46	4,883
day-care shared space (infant)	1	287	287	23,718	82.64	4,032
day-care shared space toddler	1	167	167	13,801	82.64	2,346
day-care shared space pre-schl	1	104	104	8,595	82.64	1,461
day-care shared space school	1	235	235	19,420	82.64	3,301
day-care motor area toddler	1	125	125	10,840	86.72	1,843
day-care motor area pre-school	1	208	208	18,674	89.78	3,175
day-care motor area school	1	235	235	21,338	90.80	3,627
day-care sensory area toddler	1	125	125	10,585	84.68	1,799
day-care sensory area pre-schl	1	208	208	17,826	85.70	3,030
day-care sensory area school	1	235	235	20,379	86.72	3,464
day-care group activities pre	1	208	208	15,280	73.46	2,597
day-care group activities schl	1	313	313	24,270	77.54	4,126
day-care learning center schl	1	313	313	24,589	78.56	4,180
work room	1	110	110	8,081	73.46	1,131
kitchen/residential	1	90	90	6,244	69.38	2,061
administration offices	1	143	143	10,651	74.48	1,704
laundry room	1	143	143	15,320	107.13	3,064
foyer	1	0	180	15,610	86.72	468
office ancillary	2	32	32	2,024	63.25	102
office	2	286	286	19,842	69.38	2,976
dining area(residence)	1	567	567	31,814	56.11	3,181
kitchen storage/residential	1	80	80	4,897	61.21	245
secretary administrative	1	120	120	8,326	69.38	1,082
hall	1	0	1,200	83,256	69.38	833
mechanical/chase	1	0	24	1,469	61.21	0
electrical	1	0	18	1,432	79.56	286
janitor	1	0	24	2,204	91.83	0
rest room(multi-person)	1	0	282	30,211	107.13	0
walls/building	1	0	1,500	61,215	40.81	0
mechanical & electrical vault	1	0	415	93,147	224.45	0
Total	35	5,833	9,476	735,175	77.58	74,834

1/06/80

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

FSI Summary

FSI	n/g	nsf	gsf	Cost	Cost/gsf	Equipment
18 DEFENSE DEPARTMENT						
1 DEFENSE DEPARTMENT						
10 CHILD CARE CENTER	0.62	5,833	9,476	735,175	77.58	74,834
Total	0.62	5,833	9,476	735,175	77.58	74,834

APPENDIX C: SARA Output of Facility CPM Schedule

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

Project Schedule Summary

Project Start Date: 1 JAN 1992

Project Completion Date: 24 JUN 1992

Total Calendar Days: 175

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

EARLY FINISH BY DAY

1 JAN 1992 --- 21 JAN 1992

ONE	L#	DESCRIPTION	W 1	T 2	F 3	S 4	S 5	M 6	T 7	W 8	T 9	F 10	S 11	S 12	M 13	T 14	W 15	T 16	F 17	S 18	S 19
1	0	BEGINNING OF PROJECT																			
SITE	418	sewer manhole						==	=												
SITE	419	sewer line trench gravel fill			=																
SITE	420	sewer pipe						=													
SITE	421	sewer trench excavation		=																	
SITE	422	sewer trench backfill			=																
SITE	423	gas service pipe			=																
SITE	424	gas line trench gravel fill			=																
SITE	425	gas trench excavation		=																	
SITE	426	gas trench backfill			=																
SITE	427	water service pipe			=																
SITE	428	water line trench gravel fill			=																
SITE	429	water trench excavation		=																	
SITE	430	water trench backfill			=																
SITE	431	water gate valves			=																
SITE	432	water valve boxes						=													
SITE	433	site drainage piping						==	=												
SITE	434	site drainage gravel fill			=																
SITE	435	site drainage trench excavation		==	=																
SITE	436	site drainage trench backfill			=																
SITE	437	power distribution wire						=													
SITE	438	power trench gravel fill			=																
SITE	439	power trench excavation		=																	
SITE	440	power trench backfill			=																
SITE	441	power distribution conduit						=													
SITE	463	communication distribution wire						=													
SITE	464	communication trench gravel fill			=																
SITE	465	communication trench excavation		=																	
SITE	466	communication trench backfill			=																
SITE	467	communication distribution conduit						=													
SITE	468	CATV distribution wire						=													
SITE	469	CATV trench gravel fill			=																
SITE	470	CATV trench excavation		=																	
SITE	471	CATV trench backfill			=																
SITE	472	CATV distribution conduit						=													
SITE	473	parking pavement							=												
SITE	474	curb and gutter							=	==	==	==									
SITE	475	base course						=													
SITE	476	spread base course						=													

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

EARLY FINISH BY DAY

PAGE 1

1 JAN 1992 --- 21 JAN 1992

W T F S S M T W T F S S M T W T F S S

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

ONE	L#	DESCRIPTION
SITE	477	base preparation
SITE	478	paint stripes
SITE	479	parking lot lighting
SITE	480	parking lot light poles
SITE	481	electric to parking lot lights
SITE	482	sidewalk, parking
SITE	483	landscape, parking
SITE	484	irrigation, parking
SITE	485	pedestrian lighting
SITE	486	pedestrian light poles
SITE	487	electric to pedestrian lights
SITE	488	sidewalk, building
SITE	489	landscape, building
SITE	490	irrigation, building landscape
SITE	491	excavate site bulk
SITE	492	backfill site and compaction
L1 AA	1	concrete, strip footing
L1 AA	3	formwork, strip footing
L1 AA	5	reinforcing, strip footing
L1 AA	7	excavation, strip footing
L1 AA	9	concrete placement, strip footing
L1 AA	11	backfill, strip footing
L1 AA	13	concrete, foundation wall
L1 AA	15	formwork, foundation wall
L1 AA	17	reinforcing, foundation wall
L1 AA	19	concrete placement, foundation wall
L1 AA	21	concrete column stem, foundation wall
L1 AA	22	concrete placement, foundation wall
L1 AA	23	reinforcing column stem, foundation wall
L1 AA	24	formwork column stem
L1 AA	25	concrete, slab on grade, 4"
L1 AA	27	formwork, slab on grade, 4"
L1 AA	29	finishing, slab on grade, 4"
L1 AA	31	reinforcing, slab on grade, 4"
L1 AA	33	concrete placement, slab on grade, 4"
L1 AA	493	fence, 5'-0" H. w/H beam posts
L1 AA	494	fence, for corner posts add, 3" dia. alum.
L1 AA	495	fence, gate, 4' wide, 5' H. 2" frame, alum.
L1 AA	506	slides, stainless steel bed, 12' long 6' H.

Project Management System

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
LAS CRUCES, NM

PROJECT NUMBER :

ESTIMATOR : SARA SYSTEMS

COORDINATOR : JAMES F. COSS

STAGE OF ESTIMATE :

EARLY FINISH BY DAY PAGE 1

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---------------------------------------------------------------------------------------------------------------------
                                                                  |1 JAN 1992 --- 21 JAN 1992
                                                                  |W  T  F  S  S  M  T  W  T  F  S  S  M  T  W  T  F  S  S
ONE  L#  DESCRIPTION                                              |1  2  3  4  5  6  7  8  9  10 11 12 13 14 15 16 17 18 19
---------------------------------------------------------------------------------------------------------------------
L1 AA  507 playground equip. horiz. monkey ladder, 14' long       |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  508 playground equip. poles, multiple purpose, 10'-6" long |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  509 playground equip. see-saw, steel, 2 units              |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  510 swings, 8 seats 8' H. plain seats                      |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  511 swings, 8 seats 12' H. plain seats                     |  |  |  |  |  |  |  |==|  |  |  |  |  |  |  |  |  |  |
L1 AA  512 playground equip. bike rack, 10' long, permanent       |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  513 playground equip. posts, tether ball set, 2-3/8" OD    |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  514 playground equip. whirlers, 8' dia.                    |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
L1 AA  515 slides, stainless steel bed, 20' long 10' H.           |  |  |  |  |  |  |  |= |  |  |  |  |  |  |  |  |  |  |
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Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

22 JAN 1992 --- 11 FEB 1992

ONE	L#	DESCRIPTION	W 22	T 23	F 24	S 25	S 26	M 27	T 28	W 29	T 30	F 31	S 1	S 2	M 3	T 4	W 5	T 6	F 7	S 8	S 9
L1	AA	29 finishing, slab on grade, 4"	**	**	**			**	**	**	**	**			**	**	*				
L1	AA	56 hollow metal door, 3x7'															=	==			
L1	AA	68 hollow metal door frame, 3x7'															=				
L1	AA	77 misc. wood blocking																=	==		
L1	AA	101 metal door frame, 3x7'															=				
L1	AA	111 metal door frame, 3x7'															=				
L1	AA	112 hollow metal door, 3x7'															=				
L1	AA	122 hollow metal door frame, 3x7'															=				
L1	AA	152 pipe, gas, black steel															=	==			
L1	AA	154 valves															=				
L1	AA	161 pipe, cast iron, no hub, 2" dia															=	==	==		
L1	AA	162 pipe, cast iron, no hub, 1 1/2 " dia															=	==	==		
L1	AA	163 pipe, copper type L, 1/2" dia.															=	==	==		
L1	AA	166 pipe, copper type L, 1/2" dia.															=	==			
L1	AA	167 pipe, cast iron, no hub, 3" dia.															=	==			
L1	AA	168 pipe, cast iron, no hub, 2" dia.															-	--	--		
L1	AA	178 urnial wall hung															=				
L1	AA	179 urnial rough-in supply, waste & vent															=				
L1	AA	181 pipe, cast iron, no hub, 3" dia.															=	==	==		
L1	AA	183 pipe, cast iron, no hub, 4" dia.															=	==	=		
L1	AA	185 pipe, copper type L, 1" dia.															=	==	==		
L1	AA	187 pipe, copper type L, 3/4" dia.															=	==	==		
L1	AA	189 valves															=	==			
L1	AA	191 water heater, 120 gallon, electric															=				
L1	AA	192 pipe, copper type L, 1 " dia.															=	==	==		
L1	AA	200 roof drain, cast iron, 6" dia															=				
L1	AA	202 cast iron pipe, 6" dia.															=	==	==		
L1	AA	306 transformer, oil filled															=	==	==		
L1	AA	337 16" open web joists, 30-50'																*			
L1	AA	339 1 1/2" steel deck (qdeck)																*	**		
L1	AA	341 rigid insulation																			
L1	AA	343 misc. angle iron															*				
L1	AA	352 hydrant															=				
L1	AA	353 sprinkler alarm															=				
L1	AA	354 sprinkler check valve															=				
L1	AA	355 sprinkler head															=	==	==		
L1	AA	357 water flow valve															=				
L1	AA	358 bypass meter															=				
L1	AA	359 pipe, steel water 3/4															=	==	==		
L1	AA	361 pipe, steel water 2"															=	==	==		
L1	AA	363 pipe, steel water 4"															=	==	==		
L1	AA	365 sprinkler head chrome, additional															=				
L1	AA	367 siamese connector															=				

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY PAGE 2

			22 JAN 1992 ---								FEB 1992										
			W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
ONE	L#	DESCRIPTION	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9
L1	AA	368 sprinkler alarm	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	369 gong & motor	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	370 batteries & solenoid	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	371 pipe, steel water 6"	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	372 fire extinguisher	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	374 fire extinguish cabinet	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	499 pipe, cast iron, 2"	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	
L1	AA	500 pipe, copper type L	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	501 valves	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	=|	|	|	|
L1	AA	516 sand for mortar, screened & washed at the pit	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	*|	|	|	

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

12 FEB 1992 --- 3 MAR 1992

ONE	L#	DESCRIPTION	W 12	T 13	F 14	S 15	S 16	M 17	T 18	W 19	T 20	F 21	S 22	S 23	M 24	T 25	W 26	T 27	F 28	S 29	S :
L1	AA	41 sheathing, 1/2", ext. wall			==			==	==	=											
L1	AA	70 aluminum, single hung window								=											
L1	AA	71 asphalt & gravel, 3 ply																			
L1	AA	73 cants																=	==		
L1	AA	75 flashing																			
L1	AA	77 misc. wood blocking	==	==																	
L1	AA	140 rooftop unit, multizone								=	==										
L1	AA	142 duct, steel galvanized, 24" dia.								=	==	==			==	==	==	==			
L1	AA	144 duct, steel galvanized, 14" dia.								=	--	--			--	--	=				
L1	AA	146 duct, steel galvanized, 10" dia.								=	==	==			==	--	==				
L1	AA	150 thermostat and controls								=											
L1	AA	156 insulation, fiberglass																	==		
L1	AA	158 test and balance								=	==	==			==	==					
L1	AA	174 exhaust fan								=											
L1	AA	175 vent piping								=											
L1	AA	185 pipe, copper type L, 1" dia.	==																		
L1	AA	187 pipe, copper type L, 3/4" dia.	==	==	==																
L1	AA	192 pipe, copper type L, 1 " dia.	==	==	==			==	==	==	==	==			==	==	==	==			
L1	AA	194 insulation																	==		
L1	AA	196 conduit, 1" dia								=	==	==			==	==	==	==	==		
L1	AA	204 outlet box								=	==	==			==	==	==	==	==		
L1	AA	208 outlet cover								=	==	==			==						
L1	AA	210 junction box								=	==										
L1	AA	212 conduit, 3/4" emt								=	==	==			==	==	==	==	==		
L1	AA	214 conduit, 1 1/2" emt								=	==	==			==	==	==	==	==		
L1	AA	226 conduit, 3/4" emt								=	==	==									
L1	AA	233 junction boxes								=											
L1	AA	235 conduit, 1" dia. emt								=	==	==			==	==	==	==	==		
L1	AA	238 switch box								=	==										
L1	AA	239 light cover								=											
L1	AA	240 conduit, 3/4" emt								=	==	==			==	==	==				
L1	AA	246 junction boxes								=											
L1	AA	250 conduit, 1" dia. emt								=											
L1	AA	256 switch box								=											
L1	AA	258 light cover								=											
L1	AA	260 conduit, 3/4" emt								=											
L1	AA	269 junction boxes								=											
L1	AA	271 conduit, 1" dia. emt								=	==	==									
L1	AA	274 switch box								=											
L1	AA	275 light cover								=											
L1	AA	276 conduit, 3/4" emt								=											
L1	AA	280 communication outlet box								=	==	==			==	==	==				
L1	AA	282 outlet cover								=	==										

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

12 FEB 1992 --- 3 MAR 1992

ONE	L#	DESCRIPTION	W 12	T 13	F 14	S 15	S 16	M 17	T 18	W 19	T 20	F 21	S 22	S 23	M 24	T 25	W 26	T 27	F 28	S 29	S
L1	AA	284 conduit, 3/4" emt								=	==	==			==	==	==	==	==		
L1	AA	286 cable trays								=	==	==			==	==	==				
L1	AA	290 conduit, 3/4" emt								=											
L1	AA	292 conduit, 1" emt								=											
L1	AA	302 conduit, 4" emt								=	==	==			==						
L1	AA	308 conduit, 4"								=	==	==									
L1	AA	333 face brick, standard									==	==			==	==	==	==	==		
L1	AA	341 rigid insulation	==	==	==			==	==	==	==	==			==	==	==	=			
L1	AA	355 sprinkler head	==	==	==			==													
L1	AA	359 pipe, steel water 3/4	==	==	==			==	-=	==	==										
L1	AA	361 pipe, steel water 2"	==																		
L1	AA	363 pipe, steel water 4"	==	==																	
L1	AA	503 conduit, 3/4"								=											
L1	BA	2 concrete, strip footing							=												
L1	BA	4 formwork, strip footing						=													
L1	BA	6 reinforcing, strip footing						=													
L1	BA	8 excavation, strip footing			=																
L1	BA	10 concrete placement, strip footing							=												
L1	BA	12 backfill, strip footing			=																
L1	BA	14 concrete, foundation wall							=												
L1	BA	16 formwork, foundation wall						=													
L1	BA	18 reinforcing, foundation wall						=													
L1	BA	20 concrete placement, foundation wall							=												
L1	BA	26 concrete, slab on grade, 4"							=												
L1	BA	28 formwork, slab on grade, 4"						=													
L1	BA	30 finishing, slab on grade, 4"							=												
L1	BA	32 reinforcing, slab on grade, 4"						=													
L1	BA	34 concrete placement, slab on grade, 4"							=												
L1	BA	36 standard steel stud, 6", ext. wall																			

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

4 MAR 1992 --- 24 MAR 1992

ONE	L#	DESCRIPTION	W 4	T 5	F 6	S 7	S 8	M 9	T 10	W 11	T 12	F 13	S 14	S 15	M 16	T 17	W 18	T 19	F 20	S 21	S 22
L1	AA	35 standard steel stud, 6", ext. wall								=	==	==			==	==	==	==	==		
L1	AA	37 gypsum wall board, ext. wall								=	==	==									
L1	AA	39 insulation, fiberglass batt, ext. wall								*	**	**			**	**					
L1	AA	43 tape & bedding joints, ext. wall															==	==	=		
L1	AA	51 thincoat															=				
L1	AA	71 asphalt & gravel, 3 ply	=																		
L1	AA	75 flashing	**	**	**			**	**	*											
L1	AA	79 load bearing studs, 20 ga. galv. 3-5/8", 16" OC								=	==	==			==	==	==	==	==		
L1	AA	81 gypsum wall board, 5/8", both sides															==	==	==		
L1	AA	83 tape & bedding joints, int wall															**	**	**		
L1	AA	85 texture															==	==	==		
L1	AA	156 insulation, fiberglass	==	==	==			==	==	==	==	==			==	==	==	=			
L1	AA	194 insulation	==	==																	
L1	AA	196 conduit, 1" dia	==	==	==			==	==	==	==	==			==	==	==	==	==		
L1	AA	198 conductor, copper #10, 3 wire															=	==	==		
L1	AA	204 outlet box	==	==																	
L1	AA	212 conduit, 3/4" emt	==	==	==			==	==												
L1	AA	216 wire, #14 copper															=	==	==		
L1	AA	218 wire, #12 copper															=	==	==		
L1	AA	220 panel board															=	==	==		
L1	AA	224 special outlet 220v								=											
L1	AA	228 wire, #8 copper															=	==			
L1	AA	235 conduit, 1" dia. emt	==	==	==			==	==	==											
L1	AA	236 wire, #12 copper															=	==	==		
L1	AA	241 wire, #8 copper															=	==			
L1	AA	242 panel board															=	==	==		
L1	AA	252 wire, #12 copper															=				
L1	AA	262 wire, #8 copper															=				
L1	AA	264 panel board															=	==	==		
L1	AA	272 wire, #12 copper															=				
L1	AA	277 wire, #8 copper															=				
L1	AA	278 panel board															=	==	==		
L1	AA	284 conduit, 3/4" emt	==	==	==																
L1	AA	294 wire, #10 copper															=				
L1	AA	296 panel boards															=	==	==		
L1	AA	300 wire, 4/0 copper															=	==	==		
L1	AA	304 panel board, main distribution															=	==	==		
L1	AA	307 wire, 500 MCM conductor															=	==	==		
L1	AA	316 smoke dectectors								=											
L1	AA	332 sound system								=	=										
L1	AA	333 face brick, standard	==	==	==			==	==	==	==	==			=						
L1	AA	335 spray on structural steel, 1 1/2".thick								=	==	==			==	==	==	==			
L1	AA	504 wire, #8 copper															=	==	==		

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

14 MAR 1992 --- 24 MAR 1992

ONE	L#	DESCRIPTION	W 14	T 5	F 6	S 7	S 8	M 9	T 10	W 11	T 12	F 13	S 14	S 15	M 16	T 17	W 18	T 19	F 20	S .:	S .2
L1	AA	505 dryer outlet								=											
L1	BA	36 standard steel stud, 6", ext. wall	=																		
L1	BA	38 gypsum wall board, ext. wall	=																		
L1	BA	44 tape & bedding joints, ext. wall	=																		
L1	BA	46 painting, masonry										=									
L1	BA	48 paint concrete walls										=									
L1	BA	50 vinyl wall paper										=									
L1	BA	52 thincoat	=																		
L1	BA	54 painting on thincoat										=									
L1	BA	59 paint door & frame, 3x7'										=									
L1	BA	82 gypsum wall board, 5/8", both sides	=																		
L1	BA	84 tape & bedding joints, int wall	=																		
L1	BA	86 texture	=																		
L1	BA	88 paint										=			==						
L1	BA	98 paint walls, 3 coat										=			==						
L1	BA	115 paint door & frame, 3x7'										=									
L1	BA	134 painting exposed metal										=			==						
L1	BA	143 duct, steel galvanized, 24" dia.	==	==	==																
L1	BA	145 duct, steel galvanized, 14" dia.	==	=																	
L1	BA	147 duct, steel galvanized, 10" dia.	==	==																	
L1	BA	157 insulation, fiberglass	==	==	==			==	==	==	==	=									
L1	BA	159 test and balance	==																		
L1	BA	199 conductor, copper #10, 3 wire	=																		
L1	BA	207 receptacle														=					
L1	BA	217 wire, #14 copper	=																		
L1	BA	219 wire, #12 copper	=																		
L1	BA	221 panel board	==	==	=																
L1	BA	223 circuit breakers			=			==	==	==	=										
L1	BA	229 wire, #8 copper	==	=																	

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

25 MAR 1992 --- 14 APR 1992

ONE	L#	DESCRIPTION	W 25	T 26	F 27	S 28	S 29	M 30	T 31	W 1	T 2	F 3	S 4	S 5	M 6	T 7	W 8	T 9	F 10	S 11	S 12
L1	AA	35 standard steel stud, 6", ext. wall	==	==	==			==													
L1	AA	55 wood paneling										=									
L1	AA	79 load bearing studs, 20 ga. galv. 3-5/8", 16" OC	==	==	==			==	==	==	==	==			==	==	==	==			
L1	AA	81 gypsum wall board, 5/8", both sides	==	==	==			==	==	==	==	=									
L1	AA	83 tape & bedding joints, int wall	==	==	==			==	==	==	==	=									
L1	AA	85 texture	==	==	==			=													
L1	AA	90 ceramic tile, walls										=			==	==	==	==	==		
L1	AA	99 paneling										=									
L1	AA	128 ceramic tile floor										=			-=						
L1	AA	129 ceramic tile base										=									
L1	AA	132 2x4'panels, with grid system complete										=			==	==	==	==	==		
L1	AA	160 lavatory rough in, complete										=			==	==	==	==	==		
L1	AA	164 lav. wall hung porc. enamel on c.i.										=			==						
L1	AA	165 water closet rough in, complete										=			==	==					
L1	AA	169 water closet, one piece, floor mntd.										=									
L1	AA	196 conduit, 1" dia	==	==																	
L1	AA	198 conductor, copper #10, 3 wire	=																		
L1	AA	216 wire, #14 copper	==																		
L1	AA	218 wire, #12 copper	==	==																	
L1	AA	222 circuit breakers										=			==	==	==	=			
L1	AA	230 circuit breaker										=			==	=					
L1	AA	232 fluorescent, 2x4' light fixture										=			==	==	==	==	==		
L1	AA	234 flexible conduit, 3/4" dia.										=			==	==	==	==	==		
L1	AA	243 circuit breakers										=			==	==	==				
L1	AA	244 fluorescent, 1x8' light fixture										=									
L1	AA	248 flexible conduit, 3/4" dia.										=									
L1	AA	266 circuit breakers										=									
L1	AA	268 incandescent recessed fixture										=			==	==					
L1	AA	270 flexible conduit, 3/4" dia.										=									
L1	AA	279 circuit breakers										=									
L1	AA	288 safety switch										=			==						
L1	AA	298 circuit breakers										=			==	==	==	=			
L1	AA	300 wire, 4/0 copper	==																		
L1	AA	305 circuit breaker										=			==	==	==	==	==		
L1	AA	309 dishwasher															=				
L1	AA	310 range															=				
L1	AA	311 cook top															=				
L1	AA	312 built in oven															=				
L1	AA	313 microwave oven															=				
L1	AA	314 garbage disposal															=				
L1	AA	315 refrigerator															=				
L1	AA	317 range hood															=				
L1	AA	318 trash compactor															=				

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

25 MAR 1992 --- 14 APR 1992

ONE	L#	DESCRIPTION	W 25	T 26	F 27	S 28	S 29	M 30	T 31	W 1	T 2	F 3	S 4	S 5	M 6	T 7	W 8	T 9	F 10	S 11	S 12
L1	AA	319 kitchen cabinets, upper										=									
L1	AA	320 kitchen cabinets, lower										=									
L1	AA	321 kitchen counter top										=									
L1	AA	327 emergency lighting										=									
L1	AA	496 med. cabinets, sliding mirror doors, 34" x 21", unlighted															*				
L1	AA	497 clothes washer															=	=			
L1	AA	498 clothes dryer															*				
L1	AA	502 breaker										=			*						
L1	AA	504 wire, #8 copper	==	==	==																
L1	AA	517 shelving pine, clear grade, no edge band, 1" x 10"										=			==	==	==	==	==		

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

15 APR 1992 --- 5 MAY 1992

ONE	L#	DESCRIPTION	W 15	T 16	F 17	S 18	S 19	M 20	T 21	W 22	T 23	F 24	S 25	S 26	M 27	T 28	W 29	T 30	F 1	S 2	S 3
L1	AA	132 2x4'panels, with grid system complete	**	**	**			**	**												
L1	AA	148 supply register								**	**	**			**	**	**	**	**		
L1	AA	149 return register								==	==	==			==	==	==	==	==		
L1	AA	232 fluorescent, 2x4' light fixture	==	==	==			==	==	==	==	==			==	==	==	==	==		
L1	AA	305 circuit breaker	==	==	==			==													

Project Management Systems

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

6 MAY 1992 --- 26 MAY 1992

ONE	L#	DESCRIPTION	W 6	T 7	F 8	S 9	S 10	M 11	T 12	W 13	T 14	F 15	S 16	S 17	M 18	T 19	W 20	T 21	F 22	S 23	S 24
L1 AA	45	painting, masonry						*	**												
L1 AA	47	paint concrete walls						*													
L1 AA	49	vinyl wall paper						*	**												
L1 AA	53	painting on thincoat						*	**												
L1 AA	58	paint door & frame, 3x7'						*													
L1 AA	87	paint						*	**	**	**	**			**	**	**	**	**		
L1 AA	89	vinyl wall paper						*	--	**											
L1 AA	97	paint walls, 3 coat						*	**	**	**	**			**	**	**	**	**		
L1 AA	102	paint door & frame, 3x7'						*													
L1 AA	107	paint door & frame, 3x7'						*	**												
L1 AA	114	paint door & frame, 3x7'						*													
L1 AA	133	painting exposed metal						*													
L1 AA	135	paint ceiling						*	**												
L1 AA	148	supply register	**	**	**			*													
L1 AA	149	return register	*																		
L1 AA	232	fluorescent, 2x4' light fixture	**	**	**			**	**												

PROJECT NAME : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

PROJECT NUMBER :

EARLY FINISH BY DAY

|27 MAY 1992 --- 16 JUN 1992

|W T F S S M T W T F S S M T W T F S S

|27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14

ONE	LN		DESCRIPTION
L1	AA	60	bb hinges
L1	AA	62	lockset
L1	AA	64	panic hardware
L1	AA	66	door closer
L1	AA	87	paint
L1	AA	97	paint walls, 3 coat
L1	AA	100	hollow core door, 3x7'
L1	AA	103	ball bearing hinges
L1	AA	104	lockset
L1	AA	105	doorstop
L1	AA	106	solid core door, 3x7'
L1	AA	108	ball bearing hinges
L1	AA	109	lockset
L1	AA	110	doorstop
L1	AA	116	ball bearing hinges
L1	AA	118	lockset
L1	AA	120	doorstop
L1	AA	124	26 oz. carpet
L1	AA	125	vinyl base
L1	AA	126	60 oz. carpet
L1	AA	127	vinyl base
L1	AA	130	vinyl floor covering
L1	AA	131	vinyl base
L1	AA	136	chalk board
L1	AA	137	bulletin board
L1	AA	170	toilet tissue dispenser, double roll
L1	AA	171	soap dispenser
L1	AA	172	mirror & shelf, flush mount
L1	AA	173	toilet cubicles, metal, floor mounted
L1	AA	176	towell dispenser
L1	AA	177	feminine napkin dispenser
L1	AA	180	toilet urinal screen
L1	AA	206	receptacle
L1	AA	237	switch, toggle, 20 amp
L1	AA	254	switch, toggle, 20 amp
L1	AA	273	switch, toggle, 20 amp
L1	AA	345	toilet tissue dispenser, double roll
L1	AA	346	soap dispenser
L1	AA	347	mirror & shelf, flush mount
L1	AA	348	toilet partition, metal, floor mounted
L1	AA	349	grab bar, 1-1/2" dia. stainless, 36"
L1	AA	350	grab bar, 1-1/2" dia. stainless, 18"
L1	AA	351	urinal screen, metal, floor mounted

```
Project Management Systems
        PROJECT NAME      : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
        PROJECT NUMBER    :

EARLY FINISH BY DAY                                          PAGE 9

------------------------------------------------------------------------------------------------
                                     |17 JUN 1992 --- 7 JUL 1992
                                     |W  T  F  S  S  M  T  W  T  F  S  S  M  T  W  T  F  S  S
ONE  L#  DESCRIPTION                 |17 18 19 20 21 22 23 24 25 26 27 28 29 30 1  2  3  4  5
------------------------------------------------------------------------------------------------
L1 AA  130 vinyl floor covering      |**|**|**|  |  |**|* |  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  138 classroom chairs          |  |  |  |  |  |  | *|  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  139 table & arm               |  |  |  |  |  |  | =|  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  206 receptacle                |==|==|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  322 booths                    |  |  |  |  |  |  | *|  |  |  |  |  |  |  |  |  |  |  |  |
```

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Project Management Systems
        PROJECT NAME      : CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)
        PROJECT NUMBER    :

EARLY FINISH BY DAY                                          PAGE 10

------------------------------------------------------------------------------------------------
                                     |8 JUL 1992 --- 28 JUL 1992
                                     |W  T  F  S  S  M  T  W  T  F  S  S  M  T  W  T  F  S  S
ONE  L#  DESCRIPTION                 |8  9  10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
------------------------------------------------------------------------------------------------
L1 AA  130 vinyl floor covering      |**|**|**|  |  |**|* |  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  138 classroom chairs          |  |  |  |  |  |  | *|  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  139 table & arm               |  |  |  |  |  |  | =|  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  206 receptacle                |==|==|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
L1 AA  322 booths                    |  |  |  |  |  |  | *|  |  |  |  |  |  |  |  |  |  |  |  |
```

APPENDIX D: SARA Output of Facility Cash Flow Projections

Cash flow analysis for project:

CHILD DEVELOPMENT CENTER (99 CHILDREN - INFANT THRU 12 YR)

START DATE: 1 JAN 92 CONTRACT: 859,893

DATE	%	PREVIOUS APPLICATION	CURRENT APPLICATION	TOTAL COMPLETED	RETAINAGE	TOTAL REMAINING
15 FEB 92	12	0	103,188	103,188	5,159	761,864
15 MAR 92	30	103,188	154,780	257,968	12,898	614,823
15 APR 92	54	154,780	206,375	464,343	21,497	417,047
15 MAY 92	78	206,375	206,374	670,717	21,497	210,673
15 JUN 92	96	206,374	154,781	825,498	21,497	55,892
15 JUL 92	100	154,781	34,395	859,893	0	0

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